DEMONSTRATION REPORT

Discrimination Using the Geonics EM63 in a Cued Interrogation Mode at Fort McClellan, AL

ESTCP Project MM-0504

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Data were collected at the former Fort McClellan to test the Geonics EM63 deployed in a cued interrogation mode. Except for one 37mm and several 60mm seed items, all munitions encountered were 75mm or 3.8” shrapnel rounds. The EM63 surveys were cued off production mode EM61 data. Polarization tensor models were fit to each surveyed anomaly. Ground truth information was used to train a statistical classifier. For small and medium items, an early time decay rate, equivalent to one that could be obtained with an EM61, provided almost as much discrimination potential as the late time decay rate. The slow rate of data acquisition and the decay curve analysis as good or better than inversion for a physics based model suggest the benefit of the extra information extracted from the EM63 is not justified by the greater costs since some level of discrimination can be obtained without complex inversion and statistical classification, using simpler instrumentation. Better instrumentation and rigorous inversion and statistical classification would still be expected to provide a richer variety of feature vectors to significantly improve discrimination.

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Executive Summary

The demonstration described in this report was conducted at the former Fort McClellan, Alabama, under project ESTCP MM-0504 “Practical Discrimination Strategies for Application to Live Sites.” The MM-0504 project is attempting to demonstrate the application of feature extraction and statistical classification to the problem of UXO discrimination. During this demonstration we tested the performance of the Geonics EM63 when deployed in a cued interrogation mode in a heavily wooded section of the Fort McClellan site. A wide range of munitions of different calibers could be encountered on the site including grenades, 37mm projectiles, 60mm mortars, 75mm shrapnel and 3.8” shrapnel rounds. Except for one 37mm and a number of 60mm seed items, all munitions encountered at the site were 75mm or 3.8” shrapnel rounds.

The EM63 surveys were cued off production mode EM61 data collected by NAEVA on behalf of Matrix Environmental, the incumbent contractor at the site. The site surveyed was heavily forested which prevented the use of traditional positional techniques such as Global Positioning Systems and Robotic Total Station. Instead a template constructed from a sturdy pool liner was used for positioning. The template was centered over each anomaly and data were then collected at 55 pre-marked station locations distributed about the center of the template. During the sixteen field days spent at the site, a total of 401 anomalies were surveyed. This translates to an average of 25 locations per day, which is a relatively slow rate of data acquisition.

Polarization tensor models were fit to each surveyed anomaly. Ground truth information from 60 of the 401 live-site anomalies, along with 18 items in the Geophysical Prove-out and 21 items measured in a test-pit were available to train a statistical classifier. Features related to shape, which are encapsulated in the relative values of the primary, secondary and tertiary polarizations, were unstable and could not be used for reliable discrimination. A feature space comprising the size and the relative-decay rate of the primary polarization was found to be effective for discrimination of the medium caliber projectiles (75mm and 3.8” shrapnel). All demonstration metrics related to discrimination of these medium caliber projectiles were met. At the operating point, all but 5 of 119 targets of interest were recommended for excavation, with 34 false alarms. If the operating point was relaxed slightly then all medium caliber projectiles would have been recovered with 51 false alarms.

Retrospective analysis revealed that excellent discrimination performance could have been obtained by using a feature space comprising an early and late time feature extracted from the object’s primary polarization. Furthermore, we found that these feature vectors could be approximated without fitting polarization tensor models to the data, and by using just seven measurement locations around the template-center. These approximate early and a late time decay features were extracted from the sounding with the slowest decay (defined as the ratio of the 20th to 1st time-channels).

The discrimination challenge was more difficult when the smaller munitions (37mm and 60mm caliber) were included. Due to the low-number of items in the test-data, it was not possible to determine the discrimination performance on the small-medium ordnance. Retrospective analysis

suggested that an early time decay estimate could have been used to recover all 37 and 60mm caliber ordnance while eliminating approximately 101 of 217 false-positives.

For both the small (37 and 60mm caliber) and medium (75mm and 3.8” caliber) items, we found that an early time decay rate, equivalent to one that could be obtained with an EM61, provided almost as much discrimination potential as the late time decay rate. The slow rate of data acquisition and the fact that decay curve analysis was as good or better than inversion for a physics based model, leads us to conclude that the benefit of the extra information extracted from the EM63 is not justified by the increased data collection, processing and interpretation costs. The results demonstrate that some level of discrimination can be obtained without complex inversion and statistical classification, and with instrumentation as simple as an EM61. This conclusion does not imply that better instrumentation or rigorous inversion and statistical classification would not provide an advantage. With better instrumentation and/or data quality we would expect to be able to use a richer variety of feature vectors (e.g. the relative values of the primary, secondary and tertiary polarizations) and thus would expect significantly improved discrimination ability.

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Acronyms

APG	Aberdeen Proving Ground
ASR	Archive Search Report
BOR	Body of Revolution
COTS	Commercial off-the-shelf
Cs	Cesium
EM	Electromagnetic
EMI	Electromagnetic induction
ERDC	Engineer Research & Development Center
ESTCP	Environmental Security Technology Certification Program
FLBGR	Former Lowry Bombing and Gunnery Range
FUDS	Formerly Used Defense Site
GPO	Geophysical Prove-Out
HE	High Explosive
IDA	Institute for Defense Analysis
IMU	Inertial Measurement Unit
MEC	Munitions and explosives of concern
MR	Munitions Response
MTADS	Multi-Sensor Towed Array Detection System
NRL	Naval Research Laboratory
PDisc	Probability of Discrimination
Pfa	Probability of False Alarm
PNN	Probabilistic Neural Network
QC	Quality Control
ROC	Receiver operating characteristic
RR	Rocket Range
RTC	Replacement Training Center
RTS	Robotic Total Station
SE1	South-East-1
SE2	South-East-2
SERDP	Strategic Environmental Research and Development Program
SNR	Signal to noise ratio
SVM	Support vector machine
SW	South-West
TEM	Time-domain electromagnetic
TEU	Technical Escort Unit
UBC-GIF	University of British Columbia – Geophysical Inversion Facility
UXO	Unexploded ordnance
WP	White Phosphorus

1 Introduction

1.1 Background

The fiscal year 2006 (FY06) Defense Appropriation contains funding for the "Development of Advanced, Sophisticated, Discrimination Technologies for UXO Cleanup" in the Environmental Security Technology Certification Program (ESTCP). In 2003, the Defense Science Board observed: "The … problem is that instruments that can detect the buried unexploded ordnance (UXO) also detect numerous scrap metal objects and other artifacts, which leads to an enormous amount of expensive digging. Typically 100 holes may be dug before a real UXO is unearthed! The Task Force assessment is that much of this wasteful digging can be eliminated by the use of more advanced technology instruments that exploit modern digital processing and advanced multi-mode sensors to achieve an improved level of discrimination of scrap from UXO."

Significant progress has been made in discrimination technology. To date, testing of these approaches has been primarily limited to test sites with only limited application at live sites. Acceptance of discrimination technologies requires demonstration of system capabilities at real UXO sites under real world conditions. Any attempt to declare detected anomalies to be harmless and requiring no further investigation will require demonstration to regulators of not only individual technologies, but an entire decision making process.

1.2 Objectives of the Demonstration

The objectives of this demonstration were to evaluate the discrimination potential of the Geonics EM63 at Fort McClellan, Alabama (AL) when deployed in a cued interrogation mode. Pasion-Oldenburg polarization tensor models were fit to each of the EM63 cued anomalies. Feature vectors extracted from those dipole fits were used to guide a statistical classification algorithm that ranked the items in order of UXO likelihood.

The first demonstration of the methodology defined in this research project was conducted at the Former Lowry Bombing and Gunnery Range (FLBGR) in Colorado during the 2006 field season. The focus of the FLBGR demonstration was on the verification of the single inversion process used to extract physics-based parameters from magnetic and electromagnetic induction (EMI) anomalies, as well as the statistical classification algorithms used to make discrimination decisions from those parameters.

The second demonstration was conducted as part of the ESTCP discrimination pilot study at Camp Sibert, AL during 2007. The objective was to find potentially hazardous 4.2" mortars. The demonstration provided another test of the methodology as well as that of the cooperative inversion process. Both cued interrogation and full coverage data collected by different demonstrators were analyzed, allowing the effect of data quality on discrimination decisions to be assessed. For the Camp Sibert discrimination study, the project team created 8 different dig-sheets from 6 different sensor combinations: (1) Multi-sensor towed array detection system (MTADS) magnetics; (2) EM61 cart (classification and size based); (3) MTADS EM61 (classification and size based); (4) MTADS EM61 and magnetics; (5) EM63; and (6) EM63 and magnetics. Effective discrimination was demonstrated for all sensor combinations, with just one

false negative for the EM63 when inverted without magnetometer location constraints. The cued interrogation EM63 data when cooperatively inverted with the magnetics data was the most effective discriminator.

2 Technology Description

2.1 Technology Development and Application

Magnetic and electromagnetic methods represent the main sensor types used for detection of UXO. Over the past 10 years, significant research effort has been focused on developing methods to discriminate between hazardous UXO and non-hazardous scrap metal, shrapnel and geology (e.g. Hart *et al*., 2001; Collins *et al*., 2001; Pasion & Oldenburg, 2001; Zhang *et al*., 2003a, 2003b; Billings, 2004). The most promising discrimination methods typically proceed by first recovering a set of parameters that specify a physics-based model of the object being interrogated. For example, in time-domain electromagnetic (TEM) data, the parameters comprise the object location and the polarization tensor (typically two or three collocated orthogonal dipoles along with their orientation and some parameterization of the time decay curve). For magnetics, the physics based model is generally a static magnetic dipole. Once the parameters are recovered by inversion, a subset of the parameters is used as feature vectors to guide either a statistical or rule-based classifier.

Magnetic and electromagnetic (EM) phenomenologies have different strengths and weaknesses. Magnetic data are simpler to collect, are mostly immune to sensor orientation and are better able to detect deeper targets. EM data are sensitive to non-ferrous metals, are better at detecting smaller items and are able to be used in areas with magnetic geology. The reason for including the Geonics EM63 cart system in this demonstration was because the information content of the data is much richer than that of the industry standard EM61 (26 time gates versus 4). With the additional information available at each sounding, the discrimination performance of the EM63 was superior to that of the EM61 with equivalent signal to noise ratio (SNR) and position and orientation uncertainties. Table 1 summarizes the components of the Sky Research EM63 survey system. More details on specific system components are provided in the text that follows.

2.1.1 Geonics EM63 Time-Domain Metal Detector

The Geonics EM63 is a pulse based multi-channel time domain electromagnetic induction instrument. The system consists of a 1 m x 1 m square transmitter coil and three coaxial 0.5 m x 0.5 m square receiver loops mounted on a two-wheel trailer. Measured voltages are averaged over 26 geometrically spaced time gates, spanning the range 180 μs to 25.14 ms.

2.1.2 Orientation Sensors

We had originally intended to use a Crossbow AHRS-400 IMU for measuring the pitch and roll of the EM63 cart. However, during initial testing in Ashland the sensor was found to be faulty. We therefore decided to use an alternative sensor. For the static data collection envisioned we used the Geomechanics MD900-TS Digital/Analog Clinometer with viscous damped sensor (http://www.geomechanics.com/pdf/products/MD900T%20IRIS,%20L00251C.pdf). This system

has a measurement range of 25 degrees in pitch and roll, with a resolution of better than 0.004 degrees and repeatability within 0.2 degrees.

Table 1. Components of the Sky Research EM63 survey system

Technology/Equipment	Description	Features
Geonics EM63 Cart	Multi-channel time-domain EM induction instrument 1 x 1 m transmitter coil and 3 - 0.5 m^2 coaxial receiver loops mounted on a Geonics standard 2 wheel cart.	26 geometrically spaced time gates EM63 coil mounted 30 centimeters (cm) above ground level (AGL)
Positioning System	Due to significant wooded areas, neither RTS nor Global Positioning System (GPS) is feasible at the site. Positioning will be determined by predefined locations on a rigid survey mat with known locations relative to the center of the mat which will be placed directly over the flagged target location.	
Orientation Sensors	Geomechanics MD900-TS Digital/Analog Clinometer	Measures pitch and roll
Data Acquisition System	Sky Research Inc. Software Data Acquisition System (DAS)	Time-stamp with 20 ms precision
Cued interrogation Strategy	Static measurements collected at 55 points marked on a semi rigid survey mat.	2 x 2.5 meter (m) survey area. Samples in a 3 lined star pattern with points separated by 15 and 20cm, and two additional rings of increasing radius (see Figure 1(b)).

2.1.3 Data Acquisition System

Sky Research's (SKY) Software data acquisition system (SDAS) was used to control, log and time-stamp the sensor data. Previous deployments made use of the SKY hardware data acquisition system (HDAS) which accepts up to eight serial inputs with the ability to time stamp all incoming instrument data to a relative accuracy of 10μS, and an absolute time accuracy of the same precision when connected to a GPS receiver with a pulse per second (PPS) output. The forested areas precluded the use of positioning systems that require extremely accurate timestamps for this deployment. Instead a template (see Figure 1(b)) was used to position the instrument at predefined survey locations where static data were acquired. The 20ms accuracy of the SDAS was perfectly adequate for this deployment mode.

Figure 1(a) Standard EM63 cart collecting discrimination mode data at the Ashland test-site. A rigid fiberglass indicator rod is mounted in the center of the coil to accurately log the survey location. Along with the inclusion of the IMU for orientation, this minimizes positional errors.

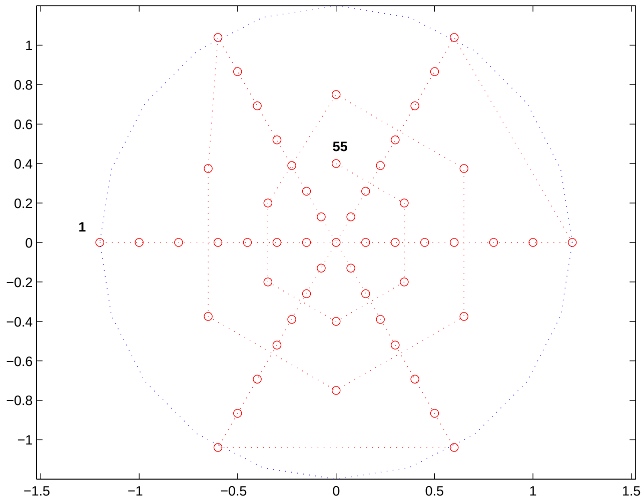


Figure 1 (b) 55 Point static data collection points. Pattern chosen based on data simulations to provide discrimination quality data with a minimum number of points for efficient surveying

2.1.4 Cued interrogation Procedure

The cued interrogation procedure consists of surveying a 2.5m x 2.5m area over pre-identified locations in a star pattern as illustrated in Figure 1(b). We will use a 2.5m by 2.25m semi-rigid plastic mat with locations marked as indicated in Figure 1(a). The survey template was always oriented so that point 1 in Figure 1(b), and the corresponding 2.5m long line, were oriented from

West to East (unless a tree or obstacle was in the way). In order to gauge instrument drift and obtain a measure of background geology, data were collected on the four corners of the template both before and after surveying. This usually placed the EM63 far enough away from the anomaly, but there were a few cases were a nearby anomaly contaminated the result. By collecting four points, we had enough redundancy so that at least two points sampled the background geology.

Pre-deployment testing in Ashland indicated that a thicker gauge plastic was preferable to a tarp as it was less likely to bunch up or shift during surveying. The weight of the mat is also substantial enough that it will not be easily windblown or require any ground intrusive means to be secured. Data were collected by pushing the EM63 so that it was centered directly over marked locations on the survey mat and held static for 2 second recording intervals. In order to ensure that the cart was centered over the indicated point on the template, a semi rigid fiberglass rod was positioned such that it extended from the center point of the coils to just above the surface.

NAEVA provided anomaly lists and maps prior to deployment to the site. The maps included an image of the EM61 response, anomaly picks (based on a 7mV threshold), and the approximate locations of trees. We manually reviewed the target lists and maps and removed any anomalies that overlapped other anomalies or that were close to trees or other obstacles. The list of suitable anomalies was significantly larger than our survey goal of 400 items. To reduce the list to 400 items, we used random selection. We first created a histogram of the anomaly amplitudes and then subjectively split the anomalies into low, medium and high SNR. Random selection was used to select about 133 anomalies from each of these categories.

The EM63 cued interrogation survey required a crew of three, which includes an experienced geophysicist and two field technicians. The geophysicist and one field technician operated the EM63, while the other field technician located the next anomaly, set up and packed up the second survey mat for the next location, moved the saw-horses etc.

The standardization and calibration tests described in Appendix A were conducted during each day of surveying.

2.1.5 Data processing

There are three key elements that impact the success of the UXO discrimination process:

1) Creation of a map of the geophysical sensor data:

   This includes all actions required to form an estimate of the geophysical quantity in question (amplitude of EMI response at a given time-channel, etc.) at each of the visited locations. The estimated quantity is dependent on the following:

   a. Hardware: including the sensor type, deployment platform, position and orientation system and the data acquisition system used to record and time-stamp the different sensors;
   b. Survey parameters: line spacing, sampling rate, calibration procedures etc.;
   c. Data processing: merging of position/orientation information with sensor data, noise and background filtering applied;

   d. The background environment: geology, vegetation, topography, cultural features, etc.; and
   e. Depth and distribution of ordnance and clutter.

2) Anomaly selection and feature extraction (described in section 2.1.5.1):

   This includes the detection of anomalous regions and the subsequent extraction of a polarization tensor model for each anomaly.

3) Classification of anomalies (described in section 2.1.5.2):

   The final objective of the demonstration is the production of a dig-sheet with a ranked list of anomalies. This was achieved via statistical classification which required training data to determine the attributes of the UXO and non-UXO classes.

The focus of this demonstration was on the further testing and validation of the methodologies for 2) and 3) above that have been developed in UXOLab jointly by Sky Research and the University of British Columbia-Geophysical Inversion Facility (UBC-GIF). The success of the discrimination process is critically dependent on the attributes of the data used for the feature extraction and subsequent classification (*vis-à-vis*, everything pertaining to the first element described above), in particular, the SNR, location accuracy, sampling density, and information content of the data (the more time channels or vector components, the more information that will be available to constrain the fits). Thus, while our intent was to test the algorithms developed in UXOLab, the test could not be conducted in isolation of the attributes of the geophysical sensor data.

We now describe the last two of the technology elements identified above.

2.1.5.1 Feature Extraction

In the EMI method, a time varying field illuminates a buried, conductive target. Currents induced in the target then produce a secondary field that is measured at the surface. EM data inversion involves using the secondary field generated by the target for recovery of the position, orientation, and parameters related to the target's material properties and shape. In the UXO community, the inverse problem is simplified by assuming that the secondary field can be accurately approximated as a dipole.

In general, TEM sensors use a step off field to illuminate a buried target. The currents induced in the buried target decay with time, generating a decaying secondary field that is measured at the surface. The time-varying secondary magnetic field $\mathbf{B}(t)$ at a location $\mathbf{r}$ from the dipole $\mathbf{m}(t)$ is:

$$\mathbf{B}(t) = \frac{\mu_o}{4\pi r^3}\mathbf{m}(t)\cdot\left(3\hat{\mathbf{r}}\hat{\mathbf{r}} - \overline{\overline{\mathbf{I}}}\right) \quad (1)$$

where $\hat{\mathbf{r}} = \mathbf{r}/|\mathbf{r}|$ is the unit-vector pointing from the dipole to the observation point, I is the 3 x 3 identity matrix, $\mu_o = 4\pi \times 10^{-7}$ H/m is the permittivity of free space and $r = |\mathbf{r}|$ is the distance between the center of the object and the observation point.

The dipole induced by the interaction of the primary field $\mathbf{B}_o$ and the buried target is given by:

$$\mathbf{m}(t) = \frac{1}{\mu_o} \overline{\overline{\mathbf{M}}}(t) \cdot \mathbf{B}_o \tag{2}$$

where $\mathbf{M}(t)$ is the target's polarization tensor. The polarization tensor governs the decay characteristics of the buried target and is a function of the shape, size, and material properties of the target. The polarization tensor is written as:

$$\overline{\overline{\mathbf{M}}}(t) = \begin{bmatrix} L_1(t) & 0 & 0 \\ 0 & L_2(t) & 0 \\ 0 & 0 & L_3(t) \end{bmatrix} \tag{3}$$

where we use the convention that $L_1(t_1) \geq L_2(t_1) \geq L_3(t_1)$, so that polarization tensor parameters are organized from largest to smallest. The polarization tensor components are parameterized such that the target response can be written as a function of a model vector containing components that are a function of target characteristics. Particular parameterizations differ depending on the instrument (number of time channels, time range measured etc) and the group implementing the work. For this study we use the Pasion-Oldenburg formulation (Pasion and Oldenburg, 2001):

$$L_i(t) = k_i (t + \alpha_i)^{-\beta_i} \exp(-t/\gamma_i) \tag{4}$$

for i={1,2,3},with the convention that $k_1 \geq k_2 \geq k_3$. For a body-of-revolution (BOR), $L_2 = L_3$ for a rod-like object (Pasion and Oldenburg, 2001) and $L_1 = L_2$ for a plate-like object.

Given a set of observations $\mathbf{d^{obs}}$, we formulate the parameter estimation as an optimization problem through Bayes theorem:

$$p(\mathbf{m} \,|\, \mathbf{d^{obs}}) = \frac{p(\mathbf{m})p(\mathbf{d^{obs}} \,|\, \mathbf{m})}{p(\mathbf{d^{obs}})} \tag{5}$$

where $\mathbf{m}$ is the vector of model parameters (location, orientation and polarization tensor parameters), $p(\mathbf{m})$ is the probability distribution representing prior information, $p(\mathbf{d^{obs}})$ is the marginal probability density of the experimental data, and $p(\mathbf{d^{obs}}|\mathbf{m})$ is the conditional probability density of the experimental data which describes the ability of the model to reproduce the experimental data. The *a-posteriori* conditional probability density $p(\mathbf{m}|\mathbf{d^{obs}})$ is the probability density we ascribe to $\mathbf{m}$ after collecting the data. The *a-posteriori* conditional probability density encapsulates all the information we have on the model parameters and the model that maximizes it is usually regarded as the solution to the inverse problem. We estimate a value of $\mathbf{m}$ that maximizes the log of the *a-posteriori* conditional probability density:

$$\mathbf{m}^* = \max_{\mathbf{m}} \left\{ \log\left(p(\mathbf{m} \,|\, \mathbf{d^{obs}}) \right) \right\} \tag{6}$$

With a single data set and no prior information on the model parameters (except maybe some bound constraints on the model parameters):

$$\text{minimize } \phi(\mathbf{m}) = \frac{1}{2}\left\| V_d^{-1/2}\left(\mathbf{d}^{\mathbf{obs}} - F(\mathbf{m})\right)\right\|^2, \text{subject to } m_i^L \leq m_i \leq m_i^U . \qquad (7)$$

where $F(\mathbf{m})$ is a vector comprising the forward modeled data at the sampled locations, m_i^L and m_i^U are the lower and upper bounds on parameter i and V_d is the co-variance matrix of the data. Efficient algorithms for the solution of this optimization problem have been implemented for various polarization tensor formulations within UXOLab (including two- and three independent polarization tensors).

2.1.5.2 Classification of Anomalies

At this stage in the process, we have feature vectors for each anomaly and now need to decide which items should be excavated as potential UXO. Rule-based classifiers use relationships derived from the underlying physics to partition the feature space. Examples include the ratio of TEM decay parameters (Pasion and Oldenburg, 2001) and magnetic remanence (Billings, 2004). For this demonstration, we focused on statistical classification techniques which have proven to be very effective at discrimination at various test-sites (e.g. Zhang *et al.*, 2003b).

Statistical classifiers have been applied to a wide variety of pattern recognition problems, including optical character recognition, bioinformatics and UXO discrimination. Within this field there is an important dichotomy between “supervised” and “unsupervised” classification. Supervised classification makes classification decisions for a test set comprised of unlabeled feature vectors. The classifier performance is optimized using a training data set for which labels are known. In unsupervised classification there is only a test set; labels are unknown for all feature vectors. Most applications of statistical classification algorithms to UXO discrimination have used supervised classification; the training data set is generated as targets are excavated. More recently, unsupervised methods have been used to generate a training data set which is an informative sample of the test data (Carin *et al*., 2004). In addition, “semi-supervised” classifiers, which exploit both labeled data and the topology of unlabeled data, have been applied to UXO discrimination in one study (Carin *et al*., 2004).

Figure 2 summarizes the supervised classification process within the statistical framework. Given test and training data sets, we extract features from the data, select a relevant subset of these features and optimize the classifier using the available training data. Because the predicted performance of the classifier is dependent upon the feature space, the learning stage can involve further experimentation with feature extraction and selection before adequate performance is achieved.

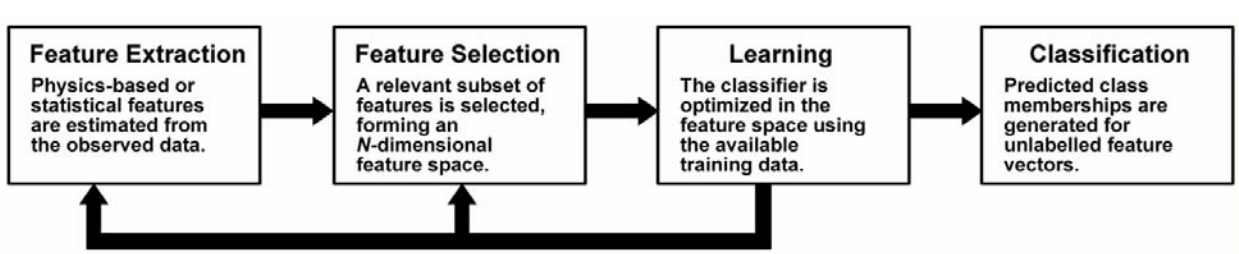


Figure 2. A framework for statistical pattern recognition.

There are two (sometimes equivalent) approaches to partitioning the feature space. The *generative* approach models the underlying probability distributions which are assumed to have produced the observed feature data. The starting point for any generative classifier is Bayes rule:

$$P(\omega_i \,|\mathbf{x}) \propto P(\mathbf{x}|\omega_i)P(\omega_i). \qquad (8)$$

The likelihood function $P(\mathbf{x}|\omega_i)$ computes the probability of observing the feature vector **x** given the class ω_i. The prior probability $P(\omega_i)$ quantifies our expectation of how likely we are to observe class ω_i. Bayes rule provides a mechanism for classifying test feature vectors: assign **x** to the class with the largest *a posteriori* probability. Contours along which the posterior probabilities are equal define decision boundaries in the feature space.

An example of a generative classifier is discriminant analysis, which assumes a Gaussian form for the likelihood function. Training this classifier involves estimating the means and co-variances of each class. If equal co-variances are assumed for all classes, the decision boundary is linear. While these assumptions may seem overly restrictive, in practice linear discriminant analysis performs quite well in comparison with more exotic methods and is often used as a baseline classifier when assessing performance.

Other generative classifiers assume a nonparametric form for the likelihood function. For example, the Probabilistic Neural Network (PNN) models the likelihood for each class as a superposition of kernel functions. The kernels are centered at the training data for each class. In this case the complexity of the likelihood function (and hence the decision boundary) is governed by the width of the kernels (Figure 3).

The *discriminative* approach is not concerned with underlying distributions but rather seeks to identify decision boundaries which provide an optimal separation of classes. For example, a Support Vector Machine (SVM) constructs a decision boundary by maximizing the *margin* between classes. The margin is defined as the perpendicular distance between support planes by which the classes are bound, as shown in Figure 4. The decision boundary then bisects the support planes. This formulation leads to a constrained optimization problem: to maximize the margin between classes, subject to the constraint that the training data are classified correctly. An advantage of the SVM method over other discriminative classifiers (e.g. neural networks) is that there is a unique solution to the optimization problem.

With all classification algorithms a balance must be struck between obtaining good performance on the training data and generalizing to a test data set. An algorithm that classifies all training data correctly may produce an overly complex decision boundary that may not perform well on the test data. In the literature this is referred to as “bias-variance trade-off” and is addressed by constraining the complexity of the decision boundary (regularization). In cases such as linear discriminant analysis, the regularization is implicit in specification of the likelihood function. Alternatively, the complexity of the fit can be explicitly governed by regularization parameters (e.g. the width of kernels in a PNN or Lagrange multipliers in a SVM). These parameters are typically estimated from the training data using *cross-validation*, which sets aside a portion of the training data to assess classifier performance for a given regularization. We will obtain our

training data from the geophysical prove-out (GPO) and from the release of data over a minimum of 50 anomalies on the live-site.

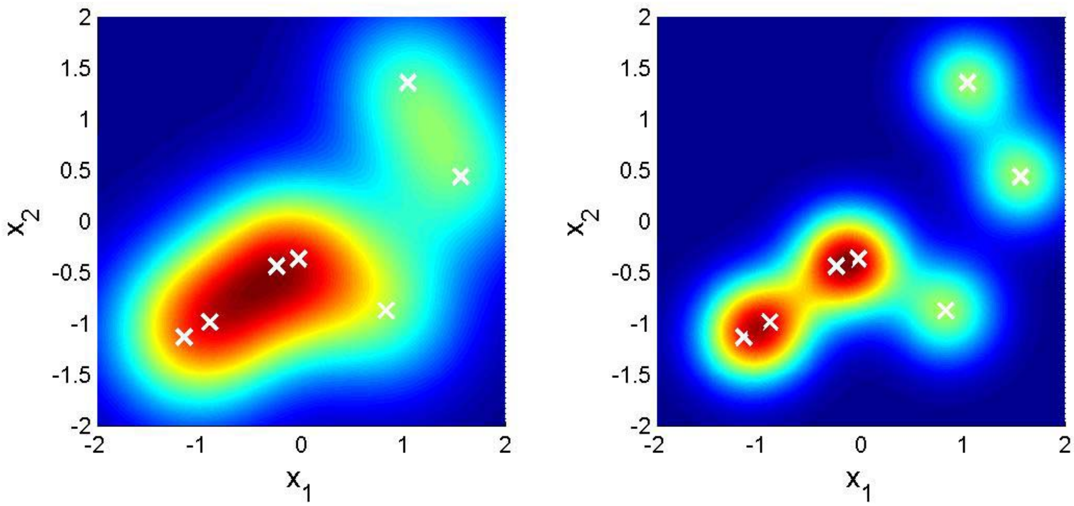


Figure 3. Nonparametric density estimate using Gaussian kernels. Kernel centers are shown as crosses. A large kernel width produces a smooth distribution (left) compared to a small kernel width (right).

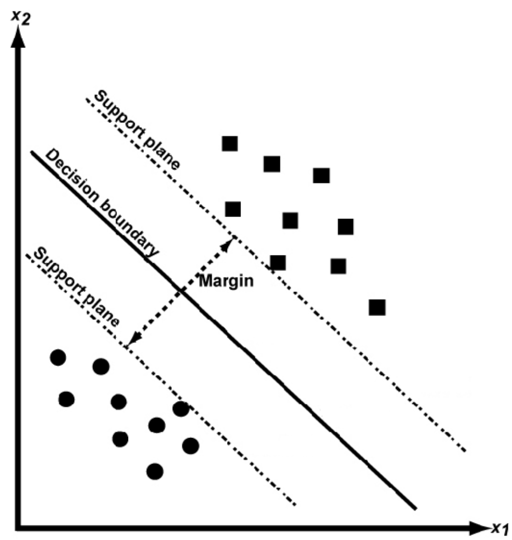


Figure 4. Support vector machine formulation for constructing a decision boundary. The decision boundary bisects support planes bounding the classes.

2.1.6 UXOLab Software

The methodologies for data processing, feature extraction and statistical classification described above have been implemented within the UXOLab software environment. This is a Matlab based software package developed over a seven year period at the UBC-GIF, principally through funding by the USACE ERDC project (DAAD19-00-1-0120). Over the past four-years, Sky Research and UBC-GIF have considerably expanded the capabilities of the software. This is the software that was used for this demonstration.

2.2 Previous Testing of the Technology

Table 2 provides a list of some of the previous testing of the underlying data processing and interpretation methodology.

The EM63 sensor system using the Leica RTS as the primary positioning system was used extensively by Sky Research Inc in 2006 and 2007. Both cued interrogation and full detection surveys were collected at the Sky Research Ashland test plot (for a period of two weeks) Marine Corps Base Camp Lejeune (for a period of four weeks), and the Former Lowry Bombing and Gunnery Range (FLBGR) (for a period of four weeks). While cued interrogation data were collected at Camp Sibert (for a period of two weeks in 2007). Discrimination results derived from full-detection surveys at the Rocket Range and the 20mm Range Fan at FLBGR are presented in Billings et al. (2007). The discrimination results for the Camp Sibert magnetometer, EM61 cart, EM61 MTADS array, and the EM63 are presented in Billings et al. (2008). Cued interrogation surveys using the proposed semi-rigid survey template shown in Figure 1 were collected over emplaced items at the Ashland test plot (for one week in 2007) in preparation for the Ft. McClellan deployment. An additional set of tests were conducted in Ashland just prior to the actual deployment to Ft. McClellan in March 2008. The results of these initial surveys are discussed in section 3.5.

Table 2. Previous Inversion/Classification Testing

Inversion/Classification Test and Location	Descripton	Results
Proof-of-concept of cooperative inversion, Yuma Proving Ground (YPG)	Test of cooperative inversion on EM63 and magnetometer data collected in 2003. TEM inversions used two decaying orthogonal dipoles, constrained using magnetics data. Three different classifiers (linear and quadratic discriminant analysis, and probabilistic neural network) were applied to the cooperative inversion results.	Classification of cooperatively inverted data is easier than inversion w/o magnetic constraints. Cleaner separation of classes is achieved for *k* parameters recovered from cooperative inversion; single and cooperative inversion results are similar for β,γ parameters. This test demonstrated the UXOLab capability to perform both cooperative inversion and statistical classification.
Geocenters STOLS EM61 and magnetometer data at Aberdeen Proving Ground (APG)/YPG	Discrimination ability of the system was marginal due to limitations in positional accuracy (5-10cm) which is inadequate for advanced discrimination); lack of sensor orientation data; low SNR; no statistical classification algorithms were applied.	Results contributed to SKY sensor systems enhancements, including the use of RTS for positioning and IMU for sensor orientation. Demonstrated the feasibility of cooperative inversion of large volumes of data with UXOLab.

Inversion/Classification Test and Location	Descripton	Results
Geonics EM61 and EM63 single inversion at the Rocket Range (RR) and 20mm Range Fan (RF) at the FLBGR. Both EM systems trialed were positioned by a Leica TPS 1206 RTS with orientation information provided by a Crossbow AHRS 400 IMU. The objectives of the RR surveys (8 acres) were the discrimination of a mixed range of projectiles with minimum diameter of 37mm from shrapnel, junk, 20mm projectiles and small-arms. The 20mm RF survey (2 acres) presented a small-item discrimination scenario where the objective was to discriminate 37mm projectiles from ubiquitous 20mm projectiles and 50 caliber bullets.	For the EM61, 3-dipole instantaneous amplitude models were fit to the available 4 time-channels, while for the EM63, 3-dipole Pasion-Oldenburg models were recovered from the 26 time-channel data. Parameters of the dipole model were used to guide a statistical classification. Canonical and visual analysis of feature vectors extracted from the test plot data indicated that discrimination could best proceed using a combination of a size and a "goodness of fit" based feature vector. A SVM classifier was then implemented based on those feature vectors and using the available training data.	Two phases of digging and training were conducted at the 20mm RF, and three phases at the RR. At the RR, twenty-nine MK-23 practice bombs were recovered, with only one other UXO encountered (a 2.5 inch rocket warhead). At the 20mm RF, thirty-eight 37mm projectiles (most of them emplaced) were recovered, as were a large number of 20mm projectiles and 50 caliber bullets. For both sites, and for both instruments, the SVM classifier outperformed a ranking based on amplitude alone. In each case, the last detected UXO was ranked quite high by the SVM classifier and digging to that point would have resulted in a 60-90% reduction in the number of false alarms. This operating point is of course unknown prior to digging. We found that using a stop-digging criteria of f=0 (mid-way between UXO and clutter class support planes), was too aggressive and more excavations were typically required for full recovery of detected UXO. Both the amplitude and SVM methods performed quite poorly on two deep (40cm) emplaced 37mm projectiles at the 20mm RF, exposing a potential weakness of the "goodness of fit" metric. Retrospective analysis revealed that thresholding on the size of the polarization tensor alone would have yielded good discrimination performance.

Inversion/Classification Test and Location	Descripton	Results
Geonics EM61 cart, MTADS EM61 array, MTADS mag array, and EM63 single and cooperative inversions at Camp Sibert. EM63 cued interrogations were positioned by a Leica TPS 1206 RTS, with orientation information provided by a Crossbow AHRS 400 IMU. The objective of the Camp Sibert surveys was the discrimination of a large target (4.2-inch mortars). The site was unusual in that the primary ordnance known to have been used at the site was the 4.2-inch mortar, thus providing a site where the discrimination is a case of identifying a single large target (4.2-inch mortar) amongst smaller pieces of 4.2-inch mortar debris and clutter.	For the EM61, 3-dipole instantaneous amplitude models were fit to the available 3 time-channels, while for the EM63, 3-dipole Pasion-Oldenburg models were recovered from the 26 time-channel data. MTADS and EM63 data were also cooperatively inverted. Parameters of the dipole model were used to guide a statistical classification.	The results for all sensor combinations were excellent, with just one false-negative for the EM63 when inverted without cooperative constraints. When inverted cooperatively, the EM63 cued interrogation was the most effective discriminator. All 33 UXO were recovered with 25 false alarms (16 of these were in the "can't analyze" category). Not counting the "can't analyze" category, the first 33 recommended excavations were all UXO. The MTADS, and MTADS cooperatively inverted were also very effective at discrimination, with all UXO recovered very early in the dig-list (e.g. for the MTADS cooperative there were just 2 false-positives by the time all 117 "can't analyze" UXO were recovered). The MTADS data set suffered from a high number of false alarms due to anomalies with a geological origin (caused by the cart bouncing up and down). In addition, the operating point was very conservative and many non-UXO were excavated after recovery of the last UXO in the dig-list. The results from the EM61 cart were also very good, although 24 false-positives were required to excavate all 105 UXO (that weren't in the "can't analyze" category). The lower data quality of the EM61 cart resulted in a larger number of "can't analyze" anomalies over metallic sources than the MTADS.

2.3 Advantages and Limitations of the Technology

The main advantage of the technology is a potential reduction in the number of non-hazardous items that need to be excavated, thus reducing the costs of UXO remediation. There are two key aspects to the demonstrated technology (1) hardware and (2) software.

On the hardware side, we are concentrating on the demonstration of the commercial off-the-shelf (COTS) EM63 sensor. As the EM63 measures only one component of a vector field, a measurement at a single location provides limited information. As a consequence, relatively dense two-dimensional measurements are required for accurate recovery of relevant target

parameters. These measurements must be very precisely positioned and oriented for discrimination to be successful. SERDP/ESTCP are sponsoring the development of several next generation sensors with multi-component receivers. These newer sensors have the potential to significantly improve the estimation of target parameters using a much lower density of measurements. Over the next few years, these sensors will likely replace the EM63. However, there will still be a large volume of data collected and processed with the older sensors, and there is no guarantee that any of the new sensors will be rugged and flexible enough for the diverse environments of the many hundreds of munitions and explosives of concern (MEC) contaminated sites in the country.

The main limitations of the EM63 sensor system relate to the slow rate of survey and the limited range of terrain/vegetation that can be traversed by the cart. Cued interrogation also introduces additional costs into the digital geophysical mapping (DGM) process in that each selected anomaly has to be visited with a second geophysical survey system. Simulations by Bell (2005) suggest that centimeter level positioning and SNR of 30 decibels (dB) are required for such systems to accurately resolve the amplitude and relative strength of the polarization components. However, demonstration results at FLBGR and Camp Sibert reported by Billings *et al*., (2007 and 2008) indicate that good discrimination performance can be obtained by the EM63 with much lower SNR and less positional precision. At FLBGR, the time decay properties of the principal polarization component were sufficient to distinguish 37mm from 20mm projectiles, and MK-23 practice bombs from clutter items due to the EM63's relatively wide measurement range of 180 μs to 25 ms. At Camp Sibert, cooperative inversion of the EM63 cued interrogation data produced a perfect ROC curve (except for 16 "can't analyze" anomalies). An advantage of the Sky Research EM63 sensor system is that all the components are COTS.

On the software side, advantages of UXOLab and the algorithms within the package include:

- All the functionality required to process raw geophysical data, detect anomalous regions, and perform geophysical inversion and discrimination.
- Algorithms for inverting magnetic and TEM data sets both separately and cooperatively using a number of different polarization tensor formulations.
- Has an extensive set of algorithms for rule-based and statistical classification algorithms.
- Configuration in a modular fashion, so that as new sensor technologies become available (e.g. new TEM systems with multi-component receivers etc), the inversion functionality will be immediately available to those new sensor systems.

3 Demonstration Design and Data Collection

3.1 Performance Objectives

Table 3 lists all the performance objectives we established for this demonstration.

Table 3. Performance Objectives

Type of Performance Objective	Primary Performance Criteria	Expected Performance (Metric)	Actual Performance (Objective Met?)
Quantitative	Survey Rate	30 anomalies / day	No
	Probability of Discrimination (PDisc) on recovered items at selected operating point	> 0.95	Yes
	False alarm rate with PDisc (recovered) = 0.95	> 50% reduction in false alarms	Yes
	False alarm rate with PDisc = 1	> 25% reduction in false alarms	Yes
	Location Accuracy of interpreted items	<0.2m	Not applicable
	Depth accuracy of interpreted items	90% within 15cm	Yes
	Accuracy of size parameter $L_1(t_1)$	Within class variation within one order of magnitude	Yes
	Accuracy of time decay parameter $L_1(t_{20})/L_1(t_1)$	Within class variation within 25%	No
	Processing Time (interpretation)	< 10 minutes operator time per anomaly	Not applicable
Qualitative	Reliability and robustness	Operator acceptance	No

3.2 Test Site Selection

The Ft. McClellan test-site was selected partly because the project could leverage the on-going clearance activities being executed by Matrix Environmental, and partly because it represented a physically challenging site to survey. Ft. McClellan occupies 18,929 acres in the City of Anniston, in Calhoun County, Alabama. To the west of Ft. McClellan are the areas known as Weaver and Blue Mountain, and to the north is the City of Jacksonville. The Talladega Forest is located east of Ft. McClellan. The portions of Ft. McClellan to be addressed lie in the north-central portion of the installation, immediately adjacent to the main cantonment area. Figure 5 shows the location of Ft. McClellan and the four Munitions Response Sites (MRSs) covered by this document.

3.3 Test Site History/Characteristics

Ft. McClellan has documented use as a military training area since 1912, when the Alabama National Guard used it for artillery training. However, the Choccolocco Mountains may have been used for artillery training by the units stationed at Camp Shipp in the Blue Mountain Area during the Spanish American War, as early as 1898. The 29th Infantry Division used areas of Ft. McClellan for training prior to being ordered to France during World War I. In 1917, Congress

authorized the establishment of Camp McClellan, and in 1929, the camp was officially designated as Ft. McClellan. Prior to World War II, the 27th Infantry Division assembled at Ft. McClellan for training, and during the war, many other units used the site for various training purposes. Following World War II, in June 1947, Ft. McClellan was put in inactive status; it was reactivated in January 1950 and the site was used for National Guard training and was selected as the site for the Army’s Chemical Corps School.

The history of Ft. McClellan, as described in the Archives Search Report (ASR) Findings [U.S. Army Corps of Engineers (USACE) 1999a] and ASR Conclusions and Recommendations (USACE 1999b), includes training activities and demonstrations that used conventional weapons (i.e., mortars, anti-tank guns, and artillery pieces). Ft. McClellan was recommended for closure under the 1995 Base Realignment And Closure Program and was officially closed in September of 1999.

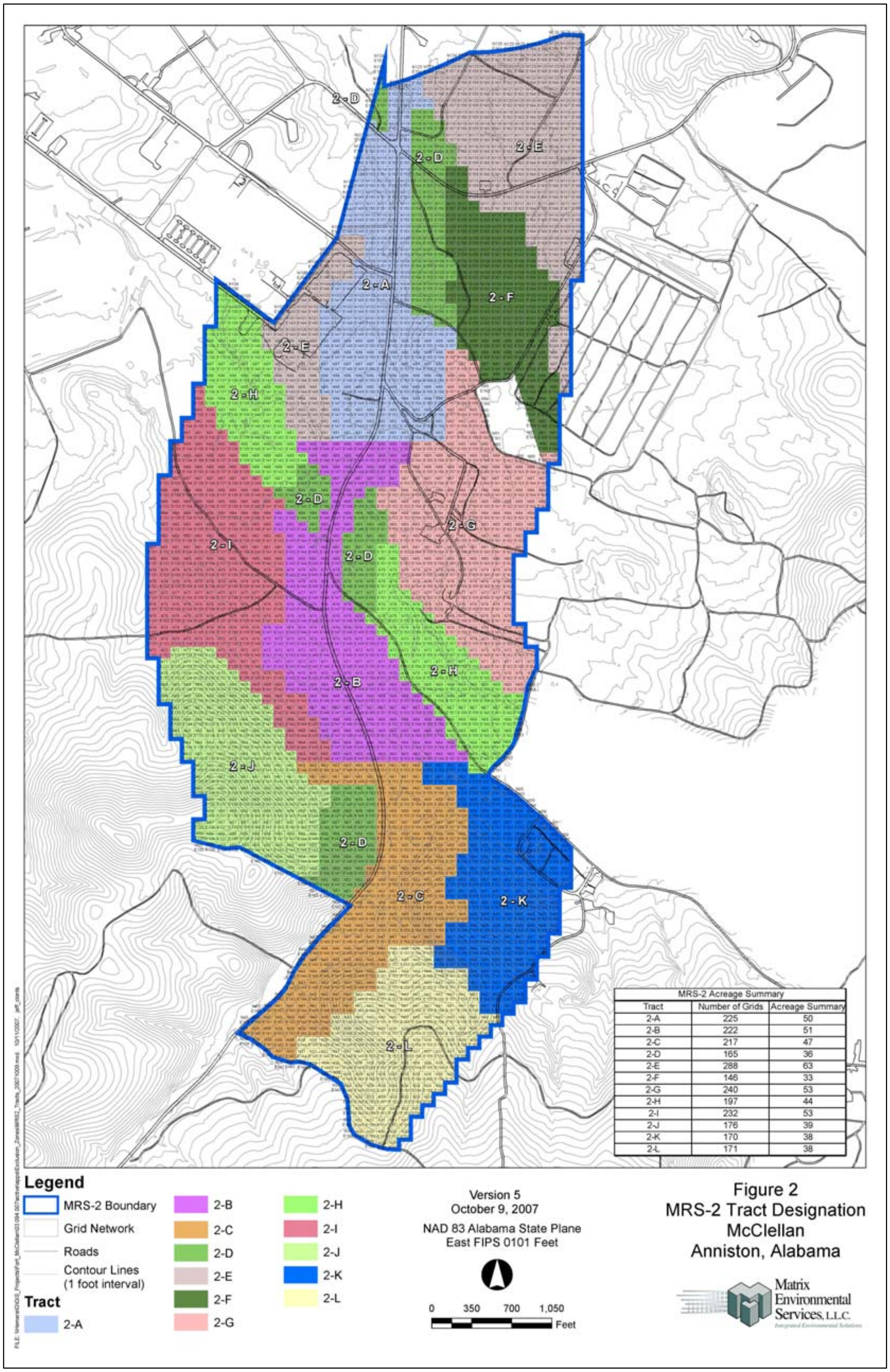
The Alpha and Bravo Munitions Response Areas (MRAs) are predominantly heavily to moderately wooded with mixed pines and hardwoods, with some open areas that were cleared for various activities during the active operation of the installation. Numerous paved and unpaved secondary roads are present, along with occasional structures, many of which are no longer used.

Ft. McClellan is situated near the southern terminus of the Appalachian Mountain chain. All but the easternmost portion of the former Main Post lie within the Valley and Ridge Province of the Appalachian Highlands. On a large scale, most of the rocks have been intensely folded into an aggregate of northeast-southwest trending anticlines and synclines with associated thrust faults. The shallow geology in the area is characterized by colluvial deposits. The presence of metamorphic rocks, as well as iron-bearing cements within the sedimentary rocks, increases the potential for minerals such as magnetite and other associated magnetic minerals.

3.4 Present Operations

The site is no longer in active use by the military. The Alpha MRA surrounds two active facilities, the Army’s former Chemical Decontamination Training Facility (CDTF) and the Military Operations in Urbanized Terrain (MOUT). The CDTF is now referred to as the COBRA (Chemical, Ordnance, Biological and Radiological) Facility and has been transferred to the United States Department of Homeland Security. The MOUT is currently owned by the Alabama National Guard.

There is an ongoing clearance effort at the site which involves multiple demolitions every day. Efforts were made to schedule the demolitions around lunch and break times to minimize stoppages, but there were several occasions when geophysical surveying had to cease temporarily.



MRS-2 Acreage Summary		
Tract	Number of Grids	Acreage Summary
2-A	225	50
2-B	222	51
2-C	217	47
2-D	165	36
2-E	288	63
2-F	146	33
2-G	240	53
2-H	197	44
2-I	232	53
2-J	176	39
2-K	170	38
2-L	171	38

Figure 5. Fort McClellan Site Map.

3.5 Pre-Demonstration Testing and Analysis

Prior to performing tests of the proposed cued interrogation approach at the Ashland test site, a series of UXOLab simulations were run to investigate what represents the optimal survey template for a range of target types. The simulations indicated that the 55 point pattern shown in Figure 1(b) represented the best trade off between acquiring high quality discrimination type data with the need to survey 400 anomalies in a reasonable amount of time.

Tests were run at the Ashland test plot in 3 different orientations for 4 sizes of targets (37mm projectile, 81mm M374 mortar, M456 Heat Rd, and white phosphorous fragment), producing a total of 12 surveyed items. The primary objectives of the tests were to ensure correct operation of all the equipment and allow the operators to become familiar with the data collection strategy. One obvious issue that became even more apparent upon review of the Ashland test data was the critical need for the anomaly under investigation to be accurately centered under the template. Consider, for example, Figure 6 which illustrates the response of a 37mm projectile buried at a depth of 15.5cm. Because the template is intentionally weighted with more points near the center of the target, the result of an off center target is a poorly sampled anomaly.

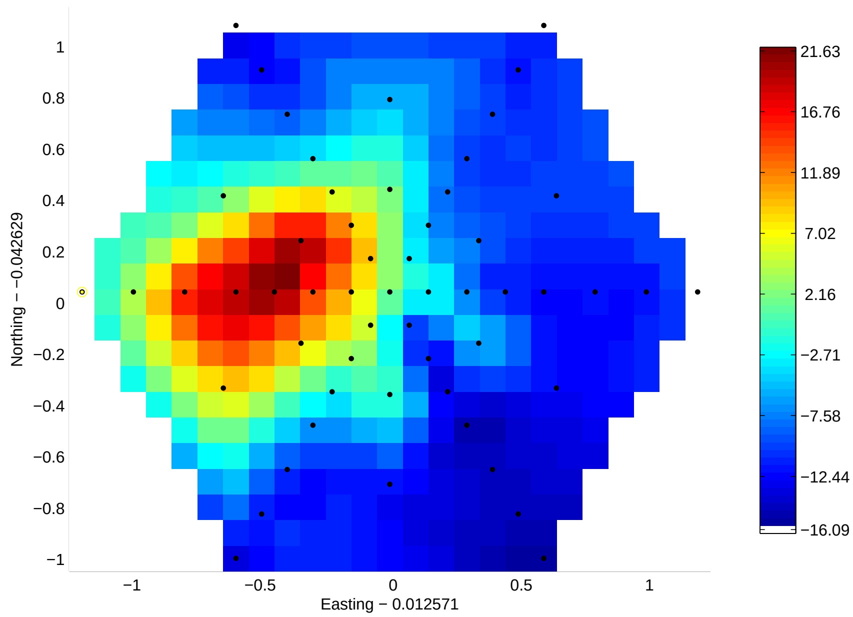


Figure 6. An example of when the template is not accurately centered over the target, resulting in a poor anomaly sample.

A secondary goal of the Ashland tests was to ensure that the complete target response would be contained within the sampled points and that enough of the background response was also collected in order to sufficiently model the background geology as well as remove any drift in the instrument through repeated points at the outer fringe of the survey template. For all four sizes of targets at typical depths, that is indeed the case as shown in Figure 7.

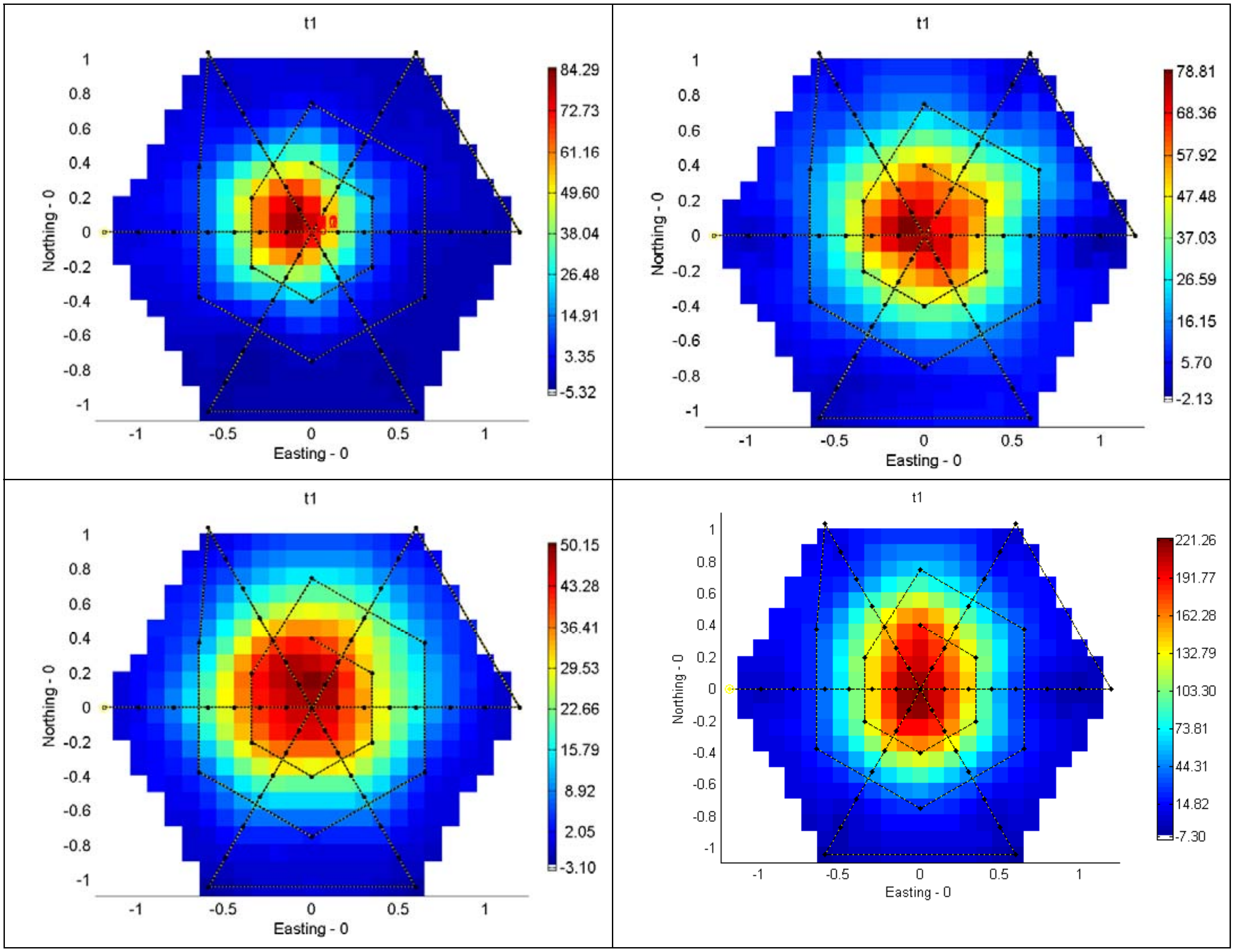


Figure 7. 37mm projectile (top left), 81mm M374 mortar (top right), M456 Heat Rd (bottom left), white phosphorous frag (bottom right).

Plotting polarization parameters for all of the items surveyed at the Ashland test plot produces a good degree of separation in the various types of targets as shown in Figure 8. One exception is a response from one of the M456 Heat rounds which corresponds to data that exhibits a strange spatial pattern, likely a result of instrument difficulties during the data acquisition process. The recovered parameters for one of the pieces of white phosphorous fragment and one of the M456 Heat rounds seem indicative of a labeling error between these two items as both anomalies seem to illustrate characteristics of the other target type.

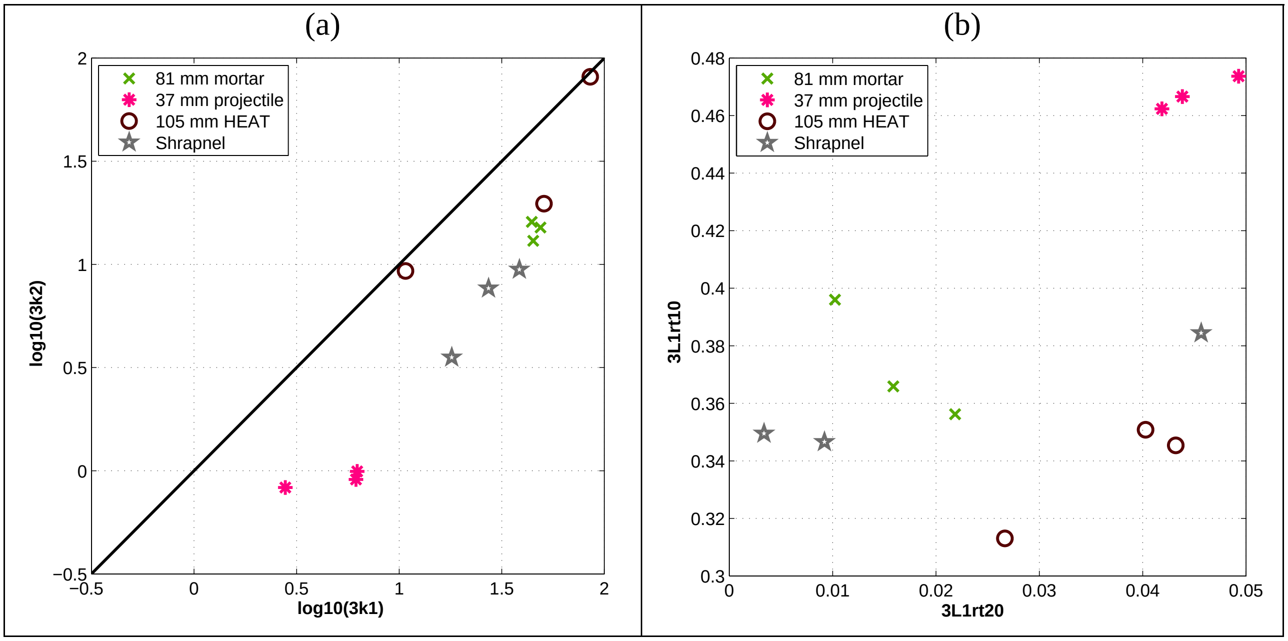


Figure 8. Feature vectors of the nine items measured at the Ashland test plot: (a) Pasion-Oldenburg k1 versus k2; (b) Ratio of the primary polarization tensor at the 10^{th} and 20^{th} time-channels over the first time channel.

3.6 Testing and Evaluation Plan

3.6.1 Demonstration Set-Up and Start-Up

Sky Research deployed to Anniston on March 16, 2008 and arrived onsite at Ft. McClellan on March 17. An inventory of the EM63 shipment that had arrived the previous week was taken after receiving a brief tour of the site from Kent Boler of Matrix. Unfortunately, FedEx had lost part of the shipment, including the cart wheels, console, batteries and some cables. A replacement EM63 was sent from the Colorado School of Mines and arrived early on the afternoon of March 17. The equipment was assembled and some simple tests were run in the parking lot to confirm that equipment was operational. On March 18, a formal site-induction took place with the NAEVA, field personnel and surveying commenced immediately afterwards. The following general procedures were followed for the survey:

- After collection of the start-of-day calibrations, the sensor operator verified correct operation of all system components prior to commencing data collection.
- For each anomaly, the third crew member set-up the template over the flagged location in preparation for the arrival of the EM63 and its two operators. The anomaly was then surveyed using the procedure outlined in section 2.1.4.
- The four corners of the survey template were surveyed before and after collecting the 55 point pattern on the template. The corners were collected to provide a static background measurement with the EM63 at a nearby, source-free location.
- The third crew member then packed up the template and moved it to the next anomaly.

We used two templates so that the EM63 was in continual use.

3.6.2 Ground Control

The survey areas were cleared of brush and any freestanding trees with a diameter of less than 3 inches prior to the geophysical field efforts. Even with this clearance, there were substantial mature trees throughout the survey area which prevented the use of either GPS or laser theodolite positioning systems. The areas were initially mapped with EM61 full coverage surveys performed by NAEVA geophysics (e.g. Figure 9). Positioning was achieved using tape measures and ropes set out from staked corner locations of 50ft x 50ft grids. Target picks were made by NAEVA personnel and an EM61 reacquisition team was deployed to confirm the location of the picked anomalies and plant labeled flags at the respective reacquired target locations. It was these flagged anomalies that were the starting point for the EM63 surveys with the survey template centered over the flagged location.

It became evident after the first few full days of surveying that the flagged locations were not always consistent with the peak of the observed EM63 response, leading to some anomalies which were poorly centered. Because the template was designed with points increasingly clustered towards the center of the template, collecting the highest quality data required the template to be accurately centered over the intended target response. To ensure centered targets, the template was placed directly over the flagged location and the EM63 was then used to scan the areas immediately surrounding the center point to ensure that the target was centered. When the maximum EM63 response did not correspond with the flagged location, the template was shifted to ensure the maximum target response was centered underneath the survey template.

Figure 9. NAEVA crew collecting EM61 data at Fort McClellan.

Because there would not be any positional information to correlate surveyed locations with flagged targets post acquisition, it was critical to accurately collect and record target information during the surveying procedure. In order to ensure accurate accounting of the targets surveyed with the EM63 three separate recordings were made for each target location:

1. The operator of the PC would enter the grid and flag label for each surveyed location into the field notes file prior to each cued anomaly recorded. Each entry in the field note file is time stamped so the chronological order of surveyed targets is captured.
2. The field crew member moving the templates would write the grid and flag label on a white board and take a digital photograph of each target location. The photographs are time stamped providing an additional record of the chronological order of surveyed targets.
3. The field crew member moving the templates would record a chronological list of the flag labels surveyed throughout the day on the respective maps of each 50ft x 50ft grid that was surveyed.

3.6.3 Validation

Initial data processing for each anomaly was performed on-site by the senior member of the survey team. This processing was done to verify the integrity of the data collected and enabled any data problems to be immediately found and rectified. Field crew members were also instructed how to identify signs of data issues on either the EM63 data console or the laptop recording the data in order to immediately identify potential data issues.

3.6.4 Period of Operation

The demonstration commenced on March 17, 2008 and was completed on April 16, 2008. A summary of activities on each day are provided in Table 4, with a more detailed description provided in Appendix C.

Table 4. Summary of on-site activities.

Day	Summary of activities
March 17, 2008	Brief tour of site, assembled CSM EM63 and collected some test data in the parking lot.
March 18, 2008	Collected data over 9 flagged targets. Member of the field crew became sick, quit for the day and get him checked out
March 19, 2008	Collected data over 5 flagged targets before heavy rains. Shut down data acquisition for the day when it appeared the rain wouldn’t let up.
March 20, 2008	Data was corrupt from first measurements of the day, current drifting widely. Troubleshooting using spare partial (NRL) system narrowed issues down to console. Shipped CSM console back to Geonics for repair, contacted Ryan North to request a loan of the USACE EM63 for the interim.
March 21, 2008	No data collection, waiting for loaner system from USACE
March 22, 2008	USACE equipment arrived at hotel, NAEVA truck came to hotel and loaded equipment to transport to the site. Arrived on site 12pm. Connected USACE console to the assembled CSM EM63 cart, console battery dead, need to charge overnight.
March 23, 2008	Site closed for Easter.

Day	Summary of activities
March 24, 2008	Collected data over 2 flagged targets before demo shot delayed surveying for an hour. On the third target (which was highest amplitude of the 3 targets surveyed), amplitudes inexplicably dropped and there was virtually no response from the target visible on the data logger. Packed up and headed back to equipment shop to run tests by replacing cables to attempt to narrow down the source of the problem. Unsuccessful, amplitudes remain low.
March 25, 2008	Assembled the entire USACE system (coils, console, cables, preamp). Collected in air static-spike-static measurement and noted that the in air spike measurement was only 1/5 of values that were previously observed. Contacted Geonics, they suggested problem was likely either in console or preamp. Tried swapping in all 3 available preamps to no avail. Issue seems traceable to console again. Geonics suggested shipping back USACE console for repair.
March 26, 2008	Received repaired CSM console via FedEx. Assembled the full CSM system, ran test in the shop parking plot to confirm that neither the drifting current nor the diminished amplitude problems were still occurring. Had to wait for a demo shot before getting access to the site, approximately one hour. In air measurements in the field also agreed well with previous data. Continued surveying over flagged targets. Collected data over 11 targets in approximately 4 hours.
March 27, 2008	Fairly productive day surveying, no equipment issues, good progress. Only delay was that we had to leave the survey area for a demo shot for approximately one hour. Collected data over 23 targets
March 28, 2008	Found that in air-static-spike measurements were reading only 40mV, a fraction of the values recorded yesterday (~500mV). Packed equipment up, drove back to shop to get phone reception to call Geonics and troubleshoot what could be causing the problem. Tried a second set of coils with new cables and also tried replacing the preamp with other 2 preamps that were available. Problem seems to be intermittent with the gains being applied. Noted that there was a detectable response observed when placing the steel sphere under the coils, even if it is a much lower amplitude than the day before. Decided to collect data over a higher amplitude (based on NAEVA's EM61 MKII picked values) buried target from the previous day to compare how amplitudes compared. Amplitudes seemed similar so decided to keep surveying to observe if a range of target amplitudes hold. Collected data over 15 targets in total
March 29, 2008	Packed equipment, headed out to the field. Found that in air-static-spike measurements were still reading only 40mV, a fraction of the values recorded previously (~500mV). Brought out a second spike target, this time a 75mm UXO from the McClellan site and found that this more substantial target produced spike values on the order of ~400mV. Collected data over 25 targets in total
March 30, 2008	Day off, no one on site. Email correspondence with Gil from Geonics to discuss issues of varying spike measurements. Sent him g63 files which illustrate the differences.

Day	Summary of activities
March 31, 2008	Only problem was the juniper logger battery died after only 6 hours. Managed to borrow a spare battery from NAEVA that we can use for the duration of the em63 measurements. Noticed that many of the targets with picked values of <10mV had no detectable change of amplitudes on the EM63 so stopped collecting data over these smaller targets. Also noticed that many of the flags were not coincident with the maximum target response as observed on the EM63 logger. Made a point of taking the time to find maximum target response and move template to center over maximum response. Takes a bit more time but less than time than having to recollect a target too far off the template center. Collected data over 24 targets.
April 1, 2008	Had to move location twice. Setup on the east side of Iron Mtn. Rd. but then ran out of targets. Had to wait for demo shot to complete then move back over to the west side. Collected data over 16 targets.
April 2, 2008	Fairly productive day, no issues with equipment or demo shots today, about as productive as we can expect for the site. Collected total of 25 targets.
April 3, 2008	Collected data over flagged items on the GPO. It was literally on the side of a hill with most locations having a meter difference in elevation from one side of the template to the other. Collected data over 18 targets. That was all that were accessible with the template of the 30 odd targets listed in the supplied ground truth table (remainder were obstructed by trees or overlapped other targets).
April 4, 2008	Productive day, managed to collect data over 23 targets by 2pm. Unfortunately that’s all that we were able to collect as a tornado warning occurred at that point, ending the day early.
April 5, 2008	Collected data over 27 targets.
April 6, 2008	Day off, site closed
April 7, 2008	Collected data over 26 targets.
April 8, 2008	Collected data over 28 targets.
April 9, 2008	Collected data over 29 targets.
April 10, 2008	A bit of a sluggish day, had to set up in 2 different grid locations, collected 26 targets.
April 11, 2008	A reasonably productive day, had to set up in 2 different grid locations, targets were much more plentiful in the second set of grids. Managed to collect 24 targets in a slightly weather shortened day.
April 12, 2008	Dug 2 pits (1 shallow, 1 deep) and collected data over 7 typical items from the site at 3 different orientations (vertical, 45 degrees, horizontal) as well as the empty pits to characterize the background. Collected data over 23 targets.
April 13, 2008	Day off, site closed
April 14, 2008	Down to a 2 person crew. Picked the most target dense grids. Collected data over 21 targets
April 15, 2008	Collected data over 25 targets
April 16, 2008	Collected data over 25 targets. Started disassembling and packing equipment
April 17, 2008	Finished disassembling and packing equipment, FedEx picked up equipment for return shipment

3.6.5 Scope of Demonstration

Cued interrogation data were collected at the Ft. McClellan ESTCP UXO Discrimination Demonstration Site, approximately 8 miles southwest of the City of Gadsden, AL. The location of 33 items in the GPO and several hundred anomalies to survey were provided by Matrix Environmental and NAEVA Geophysics. A 2.5 m by 2.5 m section of data were collected around 401 anomalies using the cued interrogation process described in Section 2.1.4. In addition to the cued interrogation surveys, the following cued interrogation surveys were conducted over:

1) Eighteen targets from the GPO; and
2) Seven typical targets (Figure 10) from the site at three unique orientations (horizontal, vertical, 45 degrees) for a total of twenty-one additional cued interrogation surveys, plus two surveys with no item to provide an estimate of the background noise.

Table 5 lists the number of anomalies surveyed in each grid, along with a count of the different types of items in each grid. Figure 11 shows some pictures emphasizing some of the data collection challenges encountered at the site.

Table 5. Count of the number of items surveyed in each grid.

Grid	Cultural debris	MEC Scrap	Medium MEC	No find	Small MEC	Small-arms	Small-medium MEC	Total
N069E143		17						17
N069E144	2	12						14
N070E143		6	9					15
N071E141	1	7					1	9
N071E142	1	9	2					12
N071E143		12	4					16
N071E144		12	1					13
N071E145		5						5
N071E146	2	4						6
N071E147		2						2
N071E148		3						3
N071E149	1	1						2
N071E150		2	1			1	1	5
N071E152		2						2
N072E141	2	5						7
N072E142	2	6						8
N072E143		16						16
N072E144	1	10	4	1				16
N072E145		2	1					3
N072E146		6	1					7
N072E147	1	4	1					6
N072E148	1	2	1					4
N072E149		1						1
N072E150		2						2
N072E151	2	2						4
N073E141	1		2					3
N073E142		5	5					10
N073E143			12					12
N073E144	1	4	9					14

Grid	Cultural debris	MEC Scrap	Medium MEC	No find	Small MEC	Small-arms	Small-medium MEC	Total
N073E148	2	1				1		4
N073E149		2				2		4
N073E150		2						2
N073E151		5						5
N074E141	1	1	1					3
N074E142	1	3	2					6
N074E143	1	3	4	1				9
N074E144	3	1	5					9
N074E148	1	2						3
N074E149	1	5	1					7
N074E150		2						2
N077E143	1	3						4
N077E144	1	5						6
N077E145		2	2					4
N077E146	5	1	1					7
N077E147	4	3	1					8
N078E143	1	3	2					6
N078E144	1	1	2			1	1	6
N078E145	1	4	2					7
N078E146	3		1					4
N078E147	1		1					2
N079E143		4	1					5
N079E144	3	3	4					10
N080E143	1	10		1		1		13
N080E144	1	5						6
N081E144	1	2						3
N082E144	3	5	1			1		10
N082E145	2	8	1				1	12
Test Pit			9	2	3		9	23
GPO			5		2		11	18
Grand Total	57	245	99	5	5	7	24	442

3.6.6 Operational Parameters for the Technology

The data were processed, features were extracted and anomalies classified using the procedures outlined in sections 4.1 to 4.3.

3.6.7 Demobilization

At the end of field operations, all equipment, materials, and supplies were removed from the site and returned to Sky Research’s head office in Ashland, Oregon. Borrowed EM63 systems were returned to the Colorado School of Mines, the US Army Corps of Engineers, and the Naval Research Lab.

3.6.8 Safety Plan

A host organization exists for this demonstration site. All field work was conducted under the authority of the existing work plan. No separate Health and Safety Plan was required.

Figure 10. Photograph of the seven items measured in the test-pit. From left to right: 37mm projectile, hand grenade, 60mm mortar, 2.5” rocket, 75mm shrapnel round, 3” stokes mortar and 3.8” shrapnel round.

3.7 Selection of Analytical/Testing Methods

Not applicable to this effort

3.8 Selection of Analytical/Testing Laboratory

Not applicable to this effort

3.9 Management and Staffing

Table 6 lists the names, titles and responsibilities of the staff used for the demonstration.

Table 6. Responsibilities of staff for the demonstration.

Personnel	Title	Responsibilities
Stephen Billings (Sky Research)	PI and QA Officer	Technical oversight of entire project, QC of collected data and construction of classifier
Joy Rogalla (Sky Research)	Project manager	Manage resources for the project, oversee the cost tracking for the demonstration
Kevin Kingdon (Sky Research)	Project Geophysicist	Data collection and initial review of data
Jon Jacobson (Sky Research)	Analyst	Perform inversions
Leonard Pasion (Sky Research)	QC	QC of inversions
Various	Field personnel	Two field personnel from NAEVA Geophysics

(a) Steep slope

(b) Rough surface

(c) Cramped survey area

Figure 11. Some of the surveying difficulties encountered on the site including (a) steep slopes; (b) rough surfaces and (c) cramped survey areas due to closely spaced trees.

3.10 Collection of ground truth

Validation sheets compiled by the EOD technicians after anomaly excavation were the primary source of information used for performance confirmation. During anomaly validation the EOD technicians (who worked under the direction of Matrix Environmental) recorded: (1) the anomaly source (UXO and type, shrapnel, junk, no-find); (2) depth of burial to the top of the item; (3) azimuth and dip (for UXO items); and (4) approximate weight (for shrapnel and junk). The dig-team also photographed any items that required demolition. We had requested that the dig-team record the bearing and distance from the flag, but this information was not recorded. A list of the ground truth information for each item is provided in Appendix F.

4 Data processing, feature extraction and classification

Once the data were collected the following three processing steps were applied:

1) Creation of a map of the geophysical data (or initial data processing);
2) Feature extraction (or inversion for the parameters of a physics based model);
3) Statistical classification (or creation of a ranked dig-list).

4.1 Creation of a map of the geophysical data

For each of the cued interrogation anomalies, the following procedure was followed:

1 Initial review of collected data*:* Confirm that data fall within prescribed recording ranges, establish number of points collected, data density, and time-on/time-off. Reject invalid clinometer or EM63 readings;

2 Data merging*:* The EM63, positioning, and orientation data are merged together so that there is one average EM63 sounding and one averaged clinometer orientation at each of the 55 points in the template.

3 Drift correction*:* Repeat measurements were made on the four-corners of the template with any difference in the repeat measurements attributed to sensor drift. For each recorded time-gate, a drift correction is applied that was a linear interpolation (as a function of time) between the average of the before and after repeat measurements.

4 Background removal*:* An estimate of the soil background (assumed constant over the breadth of the template) is calculated for each time-channel using the median value of the lowest 50% of the measurements (to avoid biasing the background estimation with signal from the metallic anomaly).

5 Data gridding*:* Filtered data are interpolated onto a 0.1m grid and reviewed by a geophysicist.

4.2 Feature extraction

For feature extraction we solve the inversion problem of Equation (7) using a 3-dipole polarization tensor as the forward model. We now describe each of the important factors involved in obtaining accurate feature vectors.

4.2.1 Data Covariance Matrix V_d

Our knowledge of the noise levels appropriate to the solution of the inverse problem is encapsulated in the data covariance matrix. We assume independently distributed Gaussian errors and use the following data covariance matrix:

$$\left[V_d^{-1/2}\right]_{ij} = \begin{cases} 0 & \text{if } i \neq j \\ \dfrac{1}{\delta_i + \varepsilon_i} & \text{if } i = j \end{cases} \qquad (8)$$

where δ_i is a percentage of the i^{th} datum:

$$\delta_i = \%error \times [d_{obs}]_i \tag{9}$$

and ε_i is a base level error that is present in the i^{th} datum in the absence of a target. For this demonstration we chose the error model as follows:

1. The *%error* term was determined by trial and error on the data collected over the GPO, the test pit and the initial release of ground truth. A value of 15% provided the best agreement between predicted and actual depths of burial; and
2. The base-line noise level was determined from the statistics of data collected over areas without any metallic anomalies present.

4.2.2 Forming the Data Vector $\mathbf{d_{obs}}$

The inversion procedure assumes that we are dealing with a single target in free space. Sensor drift, background geology, and nearby targets are non-random errors in the data that bias the estimated polarization parameters. By appropriately de-trending the data and masking the individual anomalies we can minimize these effects.

<u>Defining the Data to be Inverted 1: Spatial coverage</u>

Once data anomalies are identified, a mask is defined that represents the spatial limits of the data to be inverted. Unlike magnetics data, an unconstrained EMI inversion is very sensitive to adjacent anomalies and to the size of the mask used in areas without nearby anomalies. The masking procedure helps ensure that signal from adjacent anomalies does not affect the inversion results. In addition, from a practical standpoint, inverting the minimum number of observations reduces the computational time.

We employ an advanced masking procedure, which fits an ellipse to contours of the anomalous target. By using an ellipse we recover a relatively smooth-shaped mask that mimics the shape of the anomaly. The main challenge is to find contours that are both smooth and close to the noise level. Including our background estimates ensures that we choose appropriate starting contour values that are both above the baseline error and that encompass all of the anomalous data.

<u>Defining the Data to be Inverted 2: Time Channels</u>

For the FLBGR demonstration, we excluded any channels with a SNR of less than 10dB from the inversion, while at Camp Sibert and in this demonstration we included time-channels down to an SNR limit of 2dB.

4.2.3 Defining the Model *F*[m]

<u>Determining if the secondary and tertiary polarizations should be constrained to be equal</u>

For this demonstration we first fit a 3-dipole model to each anomaly. On the test-pit data, the secondary and tertiary polarizations were found to be approximately equal for many of the ordnance items (e.g. Figure 12(a)), indicating that the data collection strategy and data quality were sufficient to constrain all three polarizations. However when inspecting the fits to ordnance items in the GPO and the initially released ground truth, we realized that the tertiary polarization

was poorly constrained for many anomalies (e.g. Figure 12(b)). At times it was difficult to determine which polarization should be considered the primary one with three possible choices: (1) largest polarization at time-channel 1; (2) largest integrated polarization; or (3) slowest decay. For the example in Figure 12(b), each polarization satisfies one of these three conditions, so a case could be made that each could be the primary polarization[1]. To reduce complexity, we decided to constrain the secondary and tertiary polarizations to be equal (2-dipole model).

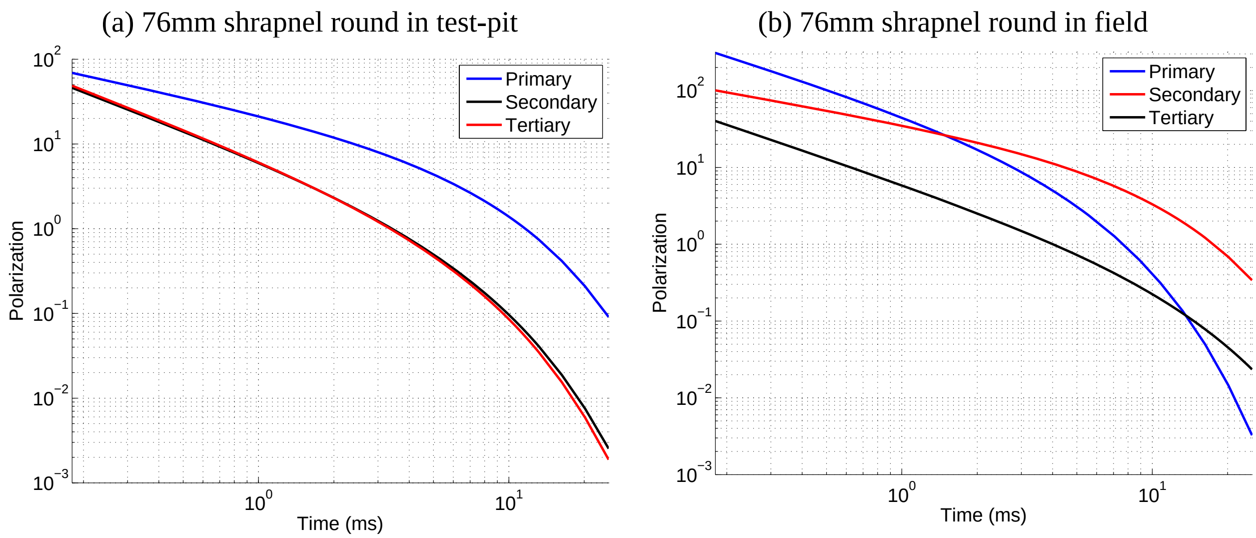


Figure 12. Recovered polarizations over two 75mm shrapnel rounds: (a) in the test-pit and (b) in the field.

Determining the parameterization of the polarization decay

There are a number of different techniques of parameterization for the temporal behavior of the polarization tensor. One common approach is to solve for the polarization value at each time channel (for example the AETC beta model which we refer to as the instantaneous amplitude polarization model). This approach is not very efficient for the 26 time-channels recorded by the EM63, and we instead used a parameterization of the polarization decay. The parameterization is inspired by the different decay regimes observed in compact targets. At very early times, the decay of the voltage will follow a $t^{-1/2}$ decay, followed by a steeper power law decay ($t^{-3/2}$ for a sphere). At the late stage of the response decays exponentially. For this study we use the following parameterized version of the polarization decay for the Geonics EM63 data:

$$L(t) = kt^{-\beta} \exp\left(-\frac{t}{\gamma}\right) \tag{10}$$

[1] Parameters extracted from the primary polarization proved to be highly discriminatory at FLBGR and Camp Sibert (Billings et al., 2007, 2008).

4.2.4 Optimization: Determining the minimum of ϕ(m)

The optimization routine we use for inversion is a local Newton-type method that minimizes the least squares objective/misfit. We address the problem of local minima and assess the level of ambiguity in resolving the depth of an item by choosing multiple starting models. We start each inversion by scanning the subsurface (x, y, z) up to a 1.2 m depth. At each position we solve for the non-diagonalized polarization tensor[2] for the first time channel (chosen for its superior signal-to-noise ratio). For each combination of a position and polarization tensor we compute a data misfit. The depth misfit curve is defined by the best fit at a given depth (Figure 14, solid line). Starting models for the full inversion of multi-channel data are selected along the depth-misfit curve among the models with relative misfit below a given threshold, here 15% (circles). If the depth-misfit curve contains local minima these are also selected as starting models.

The iterative Newton-type inversion then proceeds with each starting model. A given search stops when the iteration reaches a set threshold (misfit tolerance or number of iterations). A final model is obtained for each of the starting models (black stars in Figure 13. In the example of Figure 13(b) there are final solutions with similar misfit spread over a 0.3 m depth range, which confirms the uncertainty in recovering depth. For comparison we show in Figure 13(a) the depth-misfit curve for a different target, where the minimum misfit is well defined as a function of depth, and therefore the depth is accurately recovered.

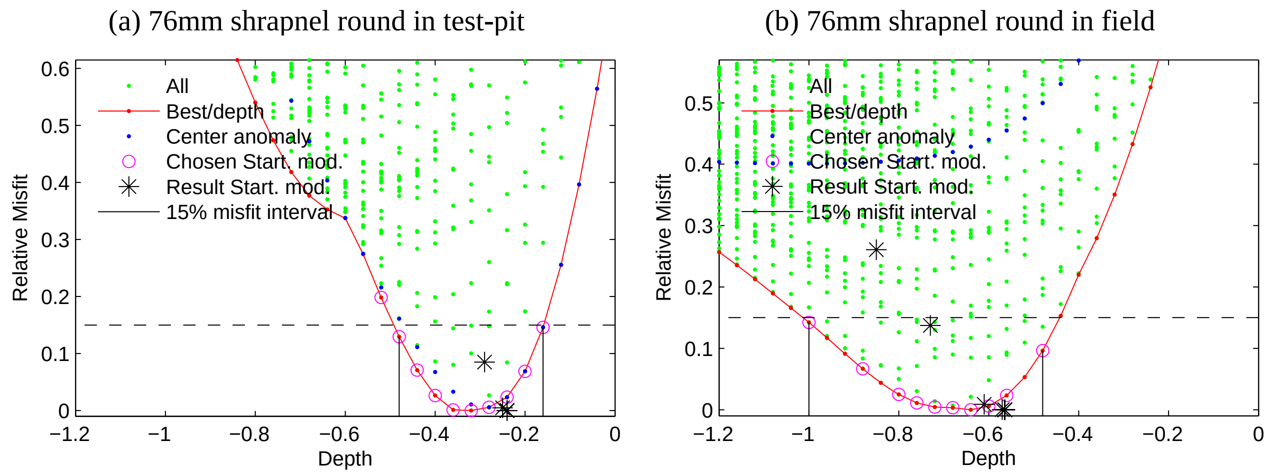


Figure 13. The depth-misfit relationship, an indirect indicator of the depth-size ambiguity for a buried object (these are the same anomalies as those shown in Figure 12). Each point corresponds to a different (x,y,z) position. In (a) solutions with similar misfit occur over a narrow range of depths, while in (b) they occur over a much wider range of depths.

4.3 Quality Control Procedures

During the first demonstration at FLBGR, we visually inspected each and every two- and three-dipole inversion for the EM61 and EM63 data sets. This proved to be a time consuming and tedious process as there were multiple views that needed to be created for each anomaly (plan-views, soundings, spatial profiles, parameters, polarization plots, termination state of

[2] When the polarization tensor is not explicitly diagonalized, the inverse problem is linear

optimization algorithm). Before the second demonstration at Camp Sibert, we created some new QC views where all relevant information for each anomaly is presented on a single page and exported to a PDF document. The QC analyst can scroll through each page of the PDF and pass or fail each fit, with the results saved in UXOLab so that only the failed anomalies need to be reconsidered. The PDF reports streamlined the QC process and significantly reduced the amount of operator time required to ensure the inversion results were of high quality. This streamlined QC process was also used for the Ft. McClellan data.

4.4 Statistical Classification

The next task in the processing flow is to determine the feature vectors to be used as the basis of discrimination and to then select, train and apply a statistical classifier to build a prioritized dig-list. For training data, we used the twenty-one test pit measurements (over seven different UXO), the eighteen items measured on the GPO, and a random selection of 60 items from the 401 measured at the site. Items used for training are marked in the table in Appendix F, with a “Training” designation; the remaining items are marked as “Test” data.

The dig-team listed an item as “Demo” if it contained, or was suspected to contain, energetic materials that made moving the round dangerous. In the sixty “live-site” ground truth items, only six items were listed as “Demo” and one item as a “QC seed” (items that had been emplaced as a QC measure). There were seventeen items listed as 75mm shrapnel round MEC scrap ranging in weight from 1 to 10 pounds, and nine items listed as 3.8” shrapnel rounds MEC scrap, ranging in weight from 1 to 15 pounds. Eight of the seventeen 75mm MEC scrap items were listed as 10 pounds, and four of the nine 3.8” MEC scrap items were listed as 15 pounds the same weights as intact specimens of these rounds. From discussions with the Senior UXO Technician at Fort McClellan, we learned that these MEC scrap items were in-fact intact projectiles that were typically only missing the lead-shot which had been blown out of the back of the round on detonation (the weight was approximately the same as an intact round as the space had filled up with dirt). We therefore decided to call any 75mm MEC scrap item of 10 pounds and any 3.8” MEC scrap item of 15 pounds an “Item of concern”. Thus these were treated exactly as if they are dangerous UXO. Later discussions revealed that these same essentially intact rounds when cleared of dirt, were listed as 7 pounds for the 75mm shrapnel rounds and 10 pounds for the 3.8” shrapnel rounds. In generating the ROC curve and assessing discrimination performance, these items were also treated as “Items of Concern”, but note that we did not use these “lighter” items during the training process.

In the training data (excluding the GPO and test-pit) there was only one small ordnance, a 60mm mortar. Within the test-data there were two more seeded 60mm mortars and just a single 37mm HE projectile. It’s not possible to conduct a statistically meaningful performance assessment on the small ordnance with such low numbers in the test-data. Therefore, for the purposes of the performance assessment, we treat the site as if the smallest item of concern is a 75mm shrapnel round. We’ll provide a brief assessment of the expected performance on the small items in a subsequent section on retrospective analysis.

Some of the feature space attributes that might prove to be suitable for discrimination are:

- The size of the item, expressed either by the value k_1, $L_1(t_1)$ or the integral of the polarization;
- "Two-dimensional" shape of the item, such as a plot of k_1 versus k_2 (see Figure 14(a));
- "Three-dimensional" shape of the item reflected in the difference between $L_2(t)$ and $L_3(t)$. If they are the same, the object has radial symmetry. This feature could not be used here as we inverted under the constraint of radial symmetry;
- Time decay information, such as the β and γ parameters (see Figures 14(b) and (c)).

From inspection of the feature space plots we deduced that a combination of object size, and time decay information would provide the most effective discrimination information (Figure 14(d)). This is the same feature space used successfully at FLBGR and Camp Sibert (Billings et al., 2007 and 2008).

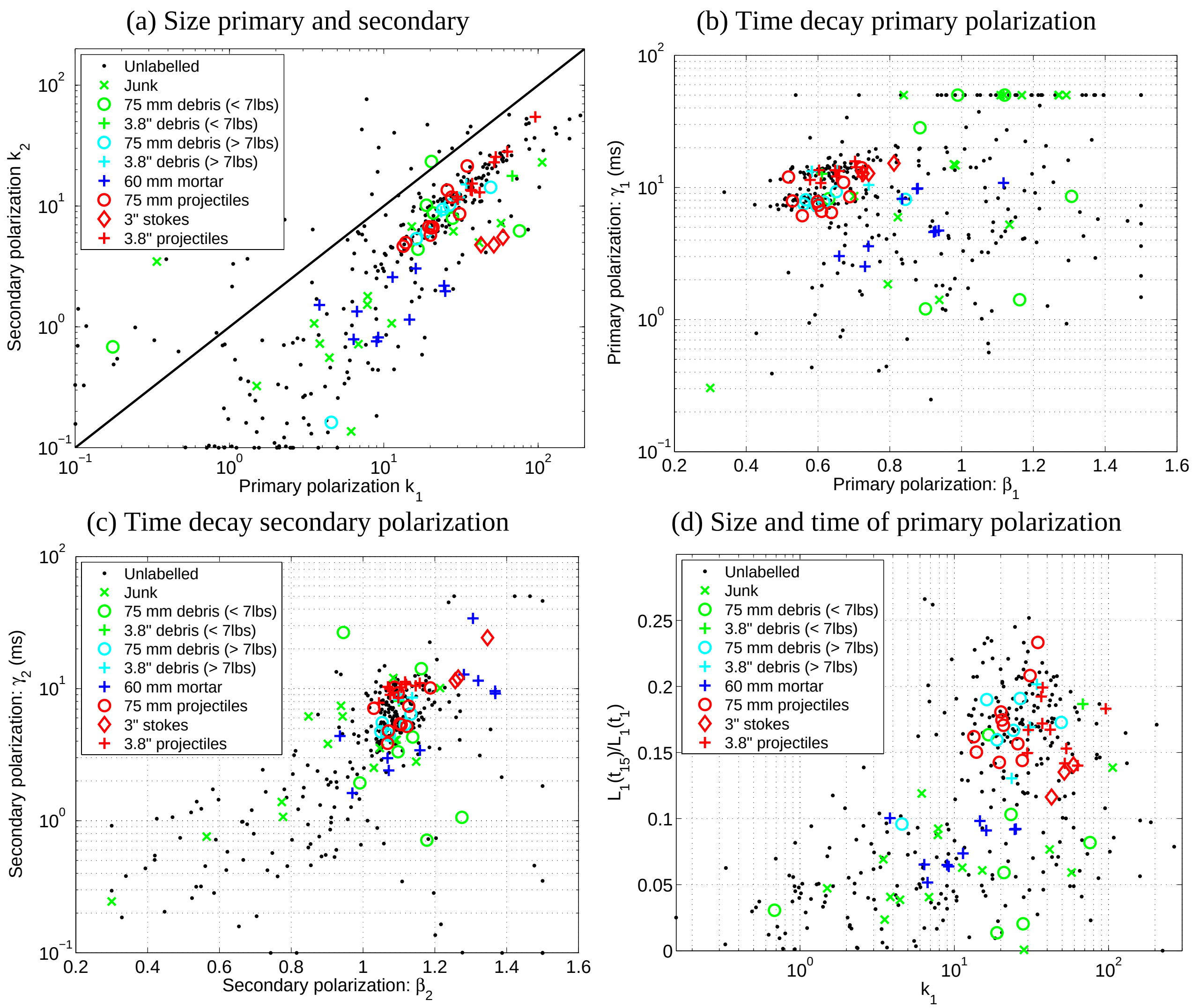


Figure 14. Feature space plots of the training data.

After investigating a support-vector machine classifier and a probabilistic neural net, we eventually settled on a quadratic discriminant analysis classifier. Visual inspection of the

decision surfaces indicated that it would provide the most effective discrimination strategy. Before training the classifier, we removed any feature vectors corresponding to 7 pound 75mm MEC scrap and 10 pound 3.8” MEC scrap items, as these overlapped the same region of feature space occupied by the targets of interest (Figure 15(a)). By visual inspection of the classification surface, we settled on a decision surface where the TOI and non-TOI probabilities were equal. Everything inside the boundary (to the top-right) is considered a TOI and would be excavated, everything outside the boundary (below and to the left) would be left in the ground. As can be seen when plotting the test-data, the decision boundary was too aggressive with two of the 75mm shrapnel rounds (anomalies 190 and 387) lying on the wrong side of the boundary. Anomaly 190 is listed as 15 pounds, with two items excavated. The fitted parameters may correspond to a smaller fragment of the round, although that possibility cannot be verified. The fit to anomaly 387 looks good across all time channels and it is listed as a single 75mm shrapnel round weighing 10 pounds. We suspect that both these feature vectors are indicative of the uncertainty in the feature extraction process and that we were too aggressive in setting the decision boundary.

If we expand the list of TOIs to include the 7 pound 75mm MEC scrap and the 10 pound 3.8” scrap, we find that there is one outlier in the training data (item 77) and three outliers in the test data (items 5, 80 and 387). Item 77 is a double peaked anomaly that also overlaps an adjacent anomaly. We suspect that the ground truth and feature vectors for item 77 correspond to different anomalies. The fit to item 5 is quite good. It is clearly a smaller item with much smaller amplitude and a faster time decay than that of an intact 75mm shrapnel round. We suspect that the ground truth is wrong. Items 80 and 392 both appear to be failures of the QC process as indicated in PDF inversion reports of Figures 16 and 17. Item 80 has a very poor fit to the late time channels, which potentially explains why the size estimate was OK, but the time decay was too fast for an intact 75mm shrapnel round. Item 392 was recovered at a depth of 120cm, and has a very low SNR, a poor spatial fit and appears to overlap an adjacent anomaly.

4.5 Dig-sheet creation

For dig-sheet creation we used a similar ranking methodology utilized during the ESTCP discrimination pilot project, except we did not include a “can’t make a decision” category:

- The first item in the list (Rank = 1) should be that which you are most certain does NOT need to be dug up (shown in green in Figure 18).
- The bottom items should be those that you are most certain are munitions and must be dug (shown in red). Thus, larger numerical rankings are associated with likely TOIs.
- A threshold should be set at the point beyond which you would recommend digging all targets, either because you are certain they are ordnance or because a high confidence determination cannot be made (heavy black dividing line in Figure 18).
- The “can’t analyze” category represents the range of targets where the SNR, data quality or other factors prevent any meaningful analysis (shown in grey).

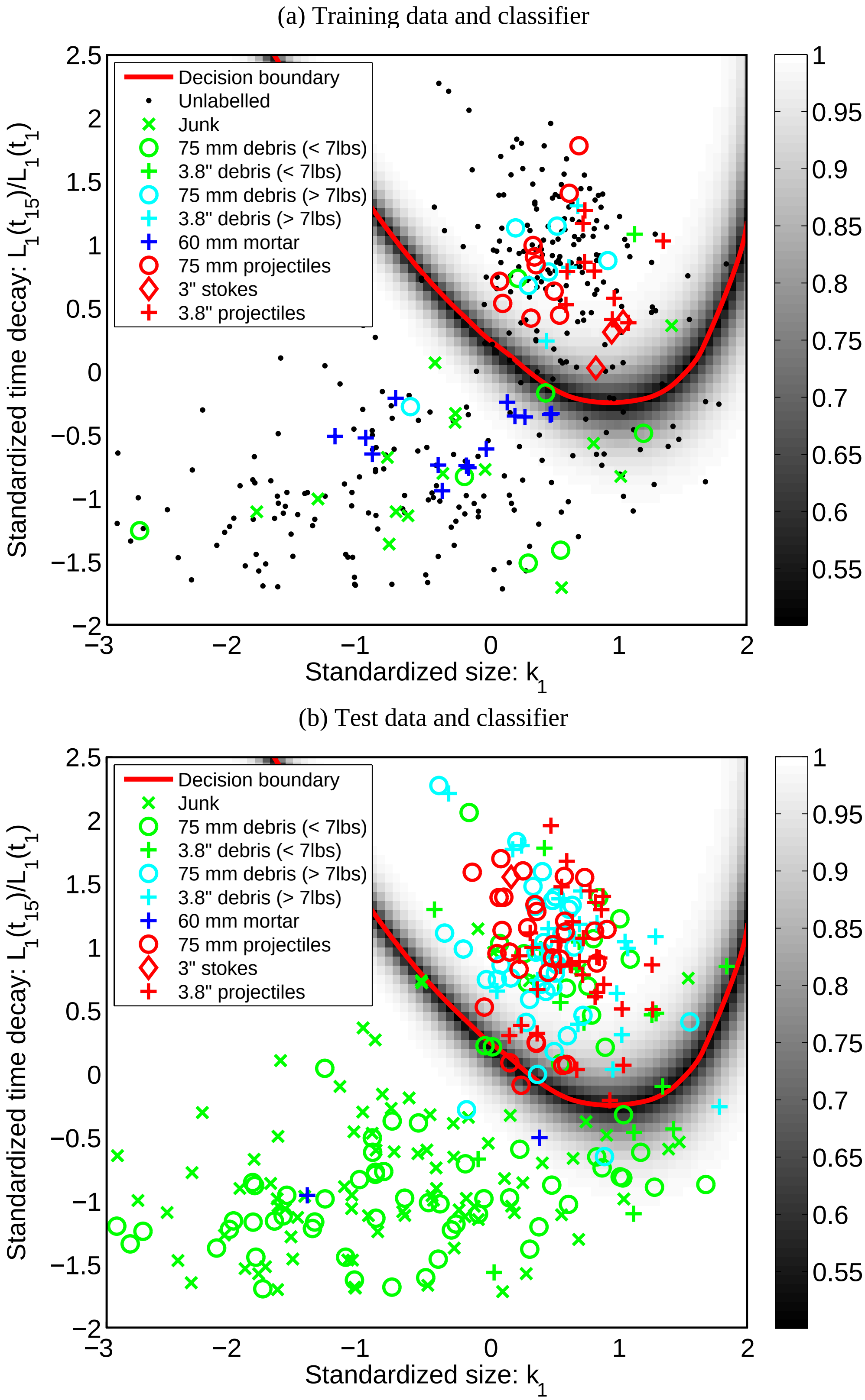


Figure 15. Quadratic discriminant analysis classification of training and test-data.

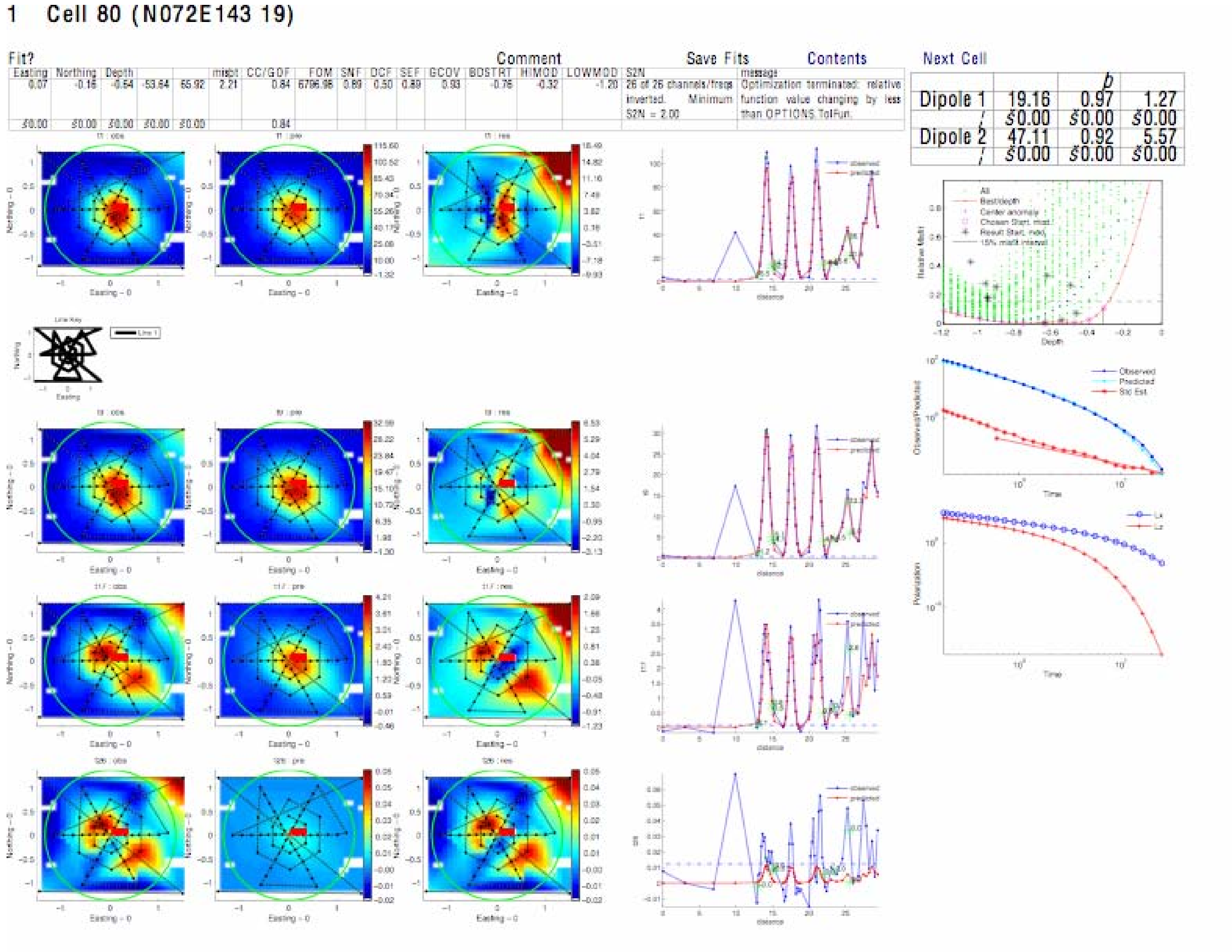


Figure 16. PDF inversion report for anomaly 80. The plan views are, from left to right, the data, the model and the residuals for time-channels 1, 9, 17 and 26. The corresponding profile views are shown next. The three plots in the far right are misfit versus depth, the sounding of the anomaly maximum and the recovered polarization tensors.

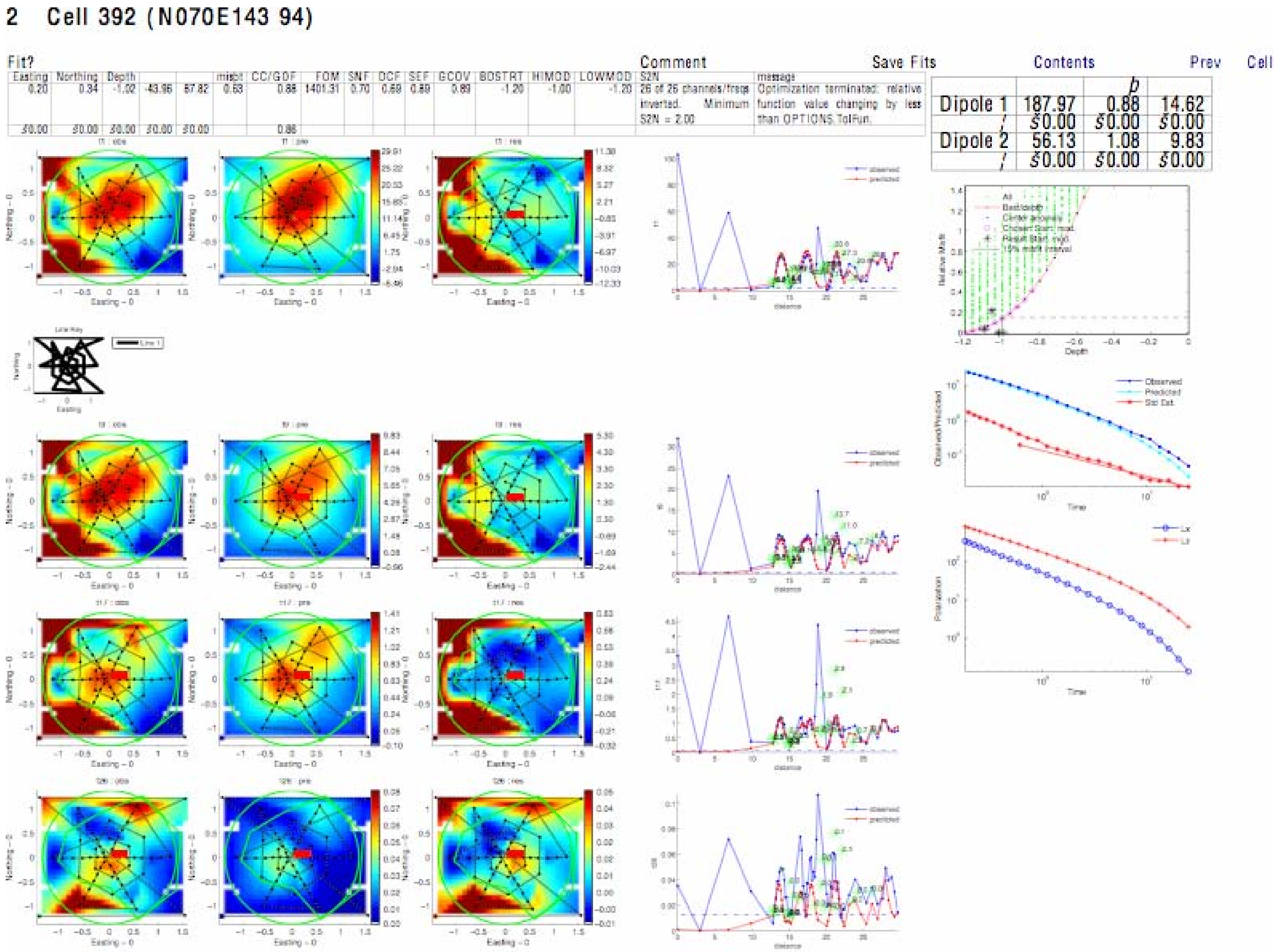


Figure 17. PDF inversion report for anomaly 392. The plan views are, from left to right, the data, the model and the residuals for time-channels 1, 9, 17 and 26. The corresponding profile views are shown next. The three plots in the far right are misfit versus depth, the sounding of the anomaly maximum and the recovered polarization tensors.

Rank	Comment
1	
2	High confidence NOT ordnance (no dig)
3	
…	
…	High confidence ordnance (dig)
…	
97	
…	“can’t analyze” (dig)
N	

Figure 18. Ranked dig-list. High numbers represent likely UXO.

The dig-sheet was created using the rules described above and in Figure 18 using the probability of TOI to create the ordering. The first item in the list has the smallest probability of being a TOI and hence is the item least like to be ordnance. In the dig-list submitted to the Program Office there were 33 “can’t analyze” items, 147 high confidence TOI and 161 high confidence NOT TOI. Figures 19(a) and (b) show two different ROC curves generated once the ground truth was released. The first ROC curve (Figure 19(a)) was generated assuming only 10 pound 75mm and 15 pound 3.8” shrapnel rounds were TOI. The second ROC curve (Figure 19(b)) was generated assuming any 75mm MEC scrap of 7 pounds or greater and any 3.8” MEC scrap of 10 pounds or greater was a TOI. We left in the two QC fails (items 80 and 392) as well as the item we suspect of having incorrect ground truth (item 5). Comparing the two ROC curves we find (first ROC curve number is listed first):

- 64 compared to 119 TOI in the test-data;
- 245 compared to 190 non-TOI in the test-data
- 62 (97%) TOI compared to 114 (96%) TOI recovered at the operating point;
- 86 non-TOI compared to 34 non-TOI excavated at the operating point; and
- 93 non-TOI compared to 64 non-TOI (51 non-TOI if we were to exclude item 5 from consideration) excavated at the point where all TOI are recovered.

Apart from setting the operating point too early, the discrimination ranking is quite efficient with 63% (first ROC) and 66% (second ROC) of non-TOI left in the ground at the point where all TOI are recovered. If we exclude item 5, then 73% of non-TOI are left in the ground.

(a) 10 lb 75mm and 15 lb 3.8” shrapnel rounds
Total of 64 TOI

(b) 7 lb 75mm and 10 lb 3.8” shrapnel rounds
Total of 120 TOI

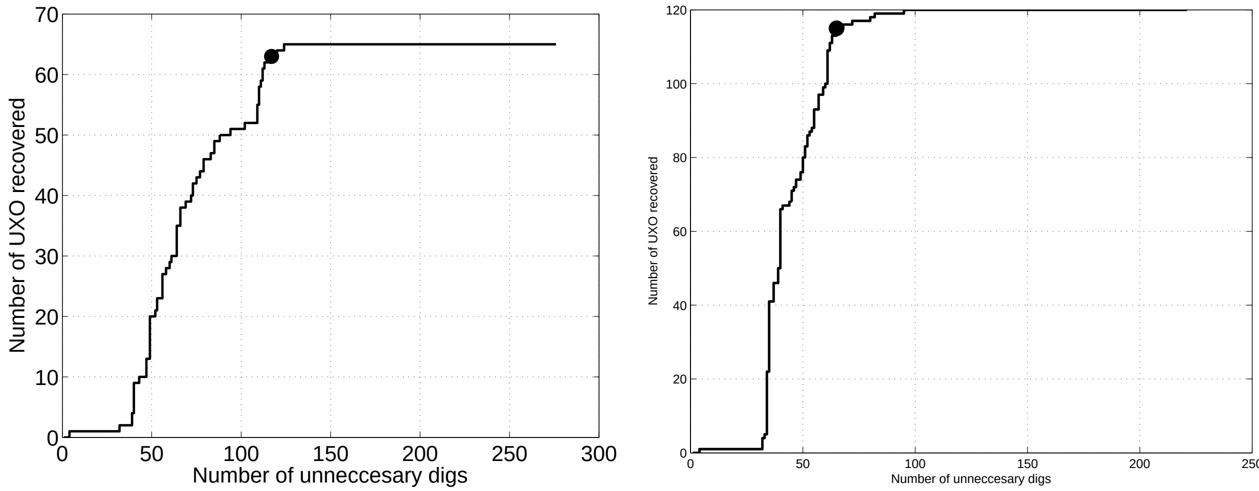


Figure 19. ROC curves corresponding to the quadratic discriminant analysis classifier of Figure 15. The ROC curve in (a) was generated assuming only 10 pound 75mm and 15 pound 3.8 shrapnel rounds were TOI. The ROC curve in (b) was generated assuming any 75mm MEC scrap of 7 pounds or greater and any 3.8” MEC scrap of 10 pounds or greater was a TOI.

5 Performance Assessment

5.1 Performance Criteria

The effectiveness of the demonstration was evaluated according to the performance objectives cited in Section 3.1, which are summarized in Table 7.

Table 7. Performance Criteria.

Performance Criteria	Description	Primary or Secondary
Probability of Discrimination (recovered)	# of MEC items detected and recommended for excavation/ # MEC items detected	*Primary*
False Alarm Rate (FAR)	# of anomalies not corresponding to an ordnance item	*Primary*
Probability of False Alarm (Pfa)	# false positives (i.e. declaration of ordnance) corresponding to clutter/# of opportunities for false positive	*Primary*
Accuracy of estimated depth	Comparison of estimated depth with ground truth depth	*Primary*
Accuracy of inversion parameters	Comparison of spread in size and time decay parameters for a given ordnance class	*Primary*
Processing Time (Interpretation)	Total minutes of operator time per anomaly	*Secondary*

5.2 Performance Confirmation Methods

Table 8 lists the specific performance confirmation methods for each metric.

Table 8. Expected Performance and Performance Confirmation Methods.

Performance Criteria	Expected Performance Metric (pre-demo)	Performance Confirmation Method	Actual (post demo)
QUANTITATIVE CRITERIA			
PDisc (recovered) at operating point	> 0.95	By reference to validation information and ranked dig-sheet	0.96
False alarm rate with PDisc = 0.95	>50% reduction in false alarms	By reference to validation information and ranked dig-sheet	86%
False alarm rate with PDisc = 1	> 25% reduction in false alarms	By reference to validation information and ranked dig-sheet	66%
Within class variation of $\log_{10}L_1(t_1)$	< 1	By reference to validation information and inversion parameters	0.96 & 1.12 (for 75mm and 3.8” TOI)
Within class variation of $L_1(t_{20})/ L_1(t_1)$	< 25%	By reference to validation information and inversion parameters	83 & 80% (for 75mm and 3.8” TOI)
Estimated depth	90% within < 0.15 m	Comparison of estimated depth with ground truth depth	60% TOI within 0.15 m
Processing Time (interpretation)	Less than 10 minutes per anomaly	Entries in data analysis log	Poor records kept
Survey rate	> 30 items/day	Entries in data collection log	25.5
QUALITATIVE CRITERIA			
Reliability and robustness	Operator acceptance	General observations	No

5.3 Performance Metrics

For evaluating the performance metrics we assume all 75mm MEC scrap of 7 pounds or greater and all 3.8” MEC scrap of 10 pounds or greater are targets of interest. The calculation of the metrics associated with probability of discrimination and false alarm were given in section 4.4.5

5.3.1 Reliability and Robustness

Objective: General observations.

Performance: Not Met.

As indicated in section 3, the data collection was hampered by technical problems in the early going. The main issues encountered were (1) loss of the intended and tested EM63 system and custom cabling during shipment to Ft. McClellan; and (2) inconsistencies in the recorded amplitudes of in air calibration measurements. The first issue was resolved by arranging to borrow EM63 systems from both the Colorado School of Mines and USACE, while the second issue was something that required consultation with the manufacturer and return of two sets of equipment for repair. The second issue that needed to be resolved was post-survey and concerned the variations in the in air calibrations of the EM63 measurements. Collected data needed to be carefully scrutinized to determine whether the collected data was valid in light of the diverging calibration measurements.

As shown in the next section, the rate of data collection was slow (average of 25.5 anomalies per day). In addition, surveying in the presence of closely spaced trees was difficult due to the large size of the EM63 and the need to survey an area of approximately 2.5 m by 2.5 m (e.g. Figure 11). The need to accurately position the cart on the template was also difficult at times due to steep slopes and rough surfaces. All these factors combined make the EM63 a relatively poor choice for surveying in wooded terrain.

5.3.2 Survey Rate

Objective: 30 anomalies / day.

Performance: 25.5 anomalies/day.

Figure 20 plots the number of anomalies that were surveyed each day. Apart from the first week when instrument difficulties limited productivity, and days which surveying was halted for demo shots, we always surveyed at least 20 items per-day. Neglecting the days of incomplete or unattempted surveying, the average survey rate was 25.5 items per day.

5.3.3 Depth accuracy of interpreted anomalies

Objective: 90% better than 15cm.

Performance: Met for 50% of all items and 60% of TOI.

Figure 21 compares the fitted and ground truth depths for all the test-data. From the cumulative distribution plot, it’s evident that only 50% of items had predicted depth within 15cm of the ground truth. A lot of the smaller shrapnel and scrap items were predicted to be significantly deeper than indicated by the ground truth. The agreement between actual and predicted depths is better if only TOI are considered, with 60% within 15cm. Note that the ground truth depths were only coarsely measured, with the deeper items only measured to within 15cm. This means that the depth accuracy is likely underestimated. However, we don’t believe we would have met the performance metric even if the ground truth information were perfect.

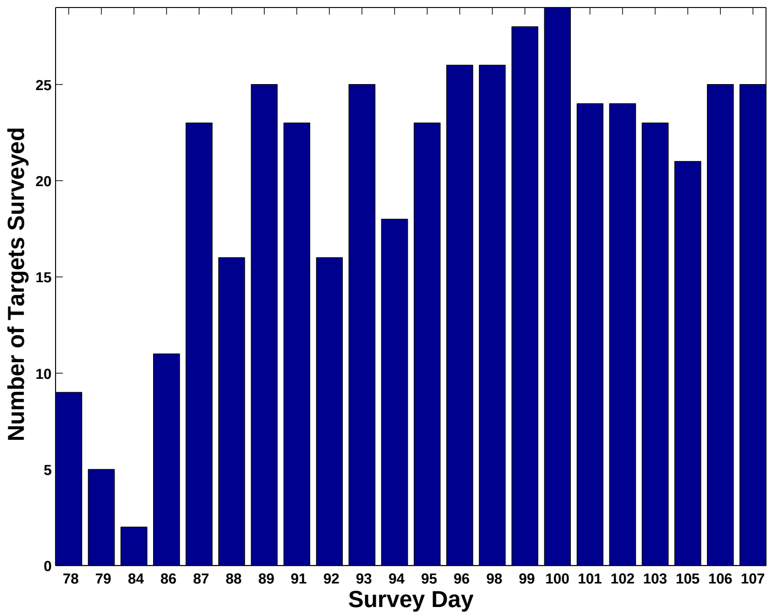


Figure 20. Number of cued interrogation anomalies surveyed each day.

(a) Predicted versus ground truth depths (b) Cumulative distribution

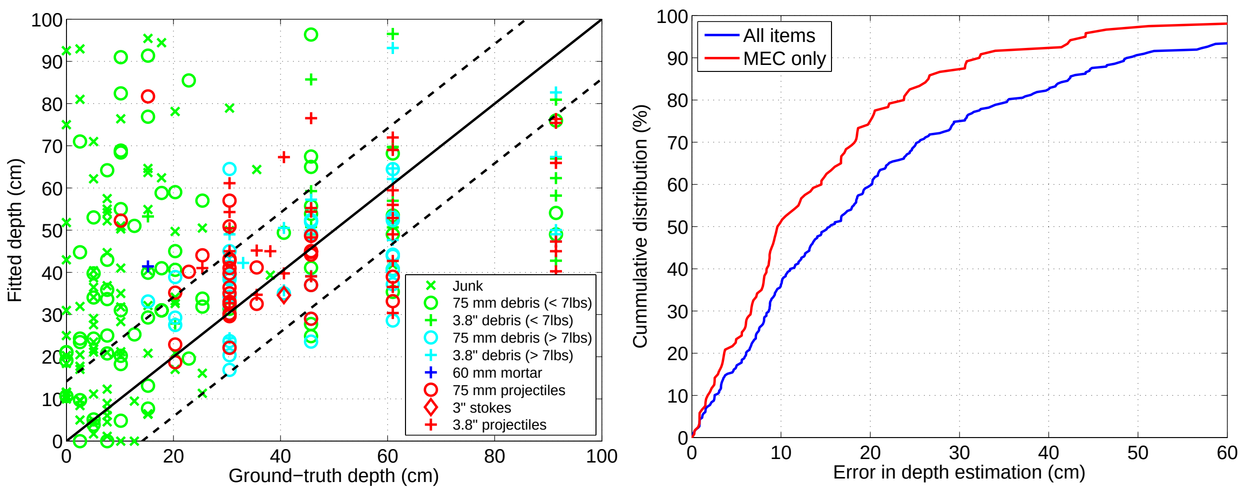


Figure 21. Comparison of ground truth versus fitted depths for test items at Fort McClellan: (a) Ground truth versus fitted depth; and (b) Cumulative distribution of the difference between ground truth and fitted depth.

5.3.4 Accuracy of size estimate

Objective: Within class variation of $\log_{10}L_1(t_1) < 1$.

Performance: Met (if we exclude one QC failure).

- For 75mm shrapnel rounds: $1.1<\log_{10}L_1(t_1) < 2.8$, with standard deviation of 0.24 (translates to a “class width” of 0.96).
- On 3.8” shrapnel rounds: $1.2<\log_{10}L_1(t_1) < 2.9$, with standard deviation of 0.28 (translates to a “class width” of 1.12).

Figure 22(a) shows a histogram of $\log_{10}L_1(t_1)$ for test items identified as 75mm shrapnel and 3.8" shrapnel rounds (including the 75mm MEC scrap of 7 pounds or greater and the 3.8" shrapnel of 10 pounds or greater), with a third category consisting of everything else. The 3.8" shrapnel round with the largest size was the QC failure identified in section 4.4 (item 392) which was recovered at a depth of 1.2m.

In the demonstration plan, we did not explicitly define the term "within class variation". We could define that as the maximum minus the minimum feature values. A more appropriate measure would be the width of the mean plus or minus two times the standard deviation (that is, four times the standard deviation). With this definition the 75mm shrapnel rounds had a within class width of 0.96 compared to 1.12 for the 3.8" shrapnel rounds (this would decrease to 1.0 if the QC failure was excluded).

(a) Object size: $L_1(t_1)$ (b) Time decay: $L_1(t_{15})/L_1(t_1)$

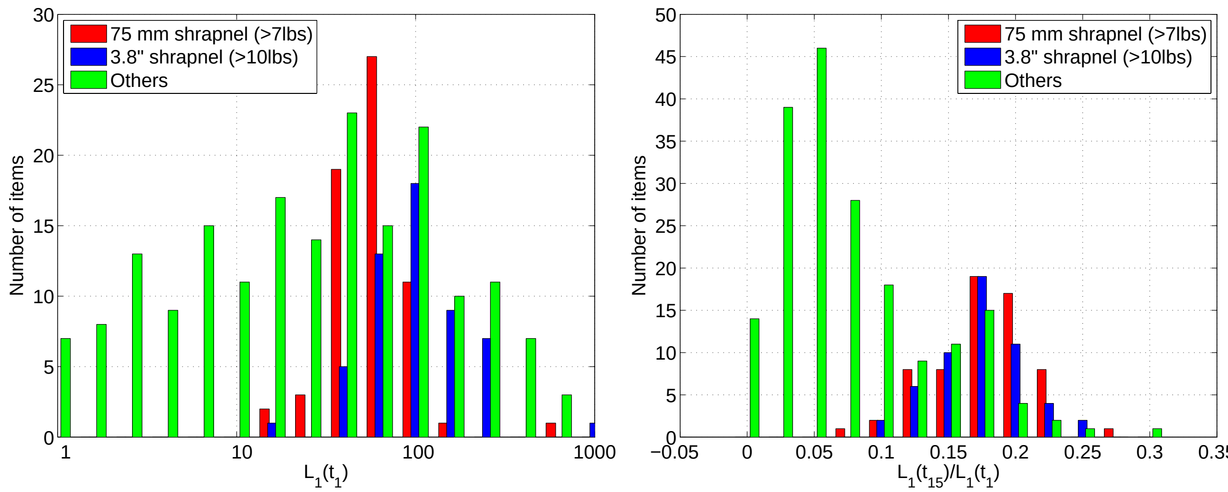


Figure 22. Histogram of (a) $L_1(t_1)$ and (b) $L_1(t_{15})/L_1(t_1)$ for test items identified as 75mm shrapnel and 3.8" shrapnel rounds (including the 75mm MEC scrap of 7 pounds or greater and the 3.8" shrapnel of 10 pounds or greater), with a third category consisting of everything else.

5.3.5 Accuracy of time decay estimate

Objective: Within class variation of $L_1(t_{20})/ L_1(t_1) < 25\%$.

Performance: Not met for both types of TOI, but this was a largely irrelevant metric.

- On 75mm shrapnel: $0.07 < L_1(t_{15})/L_1(t_1) < 0.2$, mean = 0.175 and standard deviation = 0.036. This translates to a class width of 83% of the mean.
- On 3.8" shrapnel: $0.1 < L_1(t_{15})/L_1(t_1) < 0.26$, mean = 0.175 and standard deviation = 0.035. This translates to a class width of 80% of the mean.

The distribution of decay rates for the 75mm and 3.8" shrapnel rounds are similar and tend to be larger than the non-TOI (Figure 22(b)). The fact that the metric was not met is largely irrelevant as this feature provided information that was highly discriminatory between TOI and non-TOI.

5.3.6 Processing time

Objective: Less than 10 minutes per anomaly.

Performance: Can't accurately determine the processing time.

Contrary to our stated intentions in the demonstration plan, we did not keep a good record of the time required to invert and then interpret each anomaly. Part of the problem was that we discovered a few minor inconsistencies in our processing software and ended up inverting each anomaly several times. In principle, 10 minutes per anomaly should be a realistic and achievable target.

5.4 Data Analysis, Interpretation and Evaluation

We now take a retrospective look at the data and investigate:

1) Whether we could build an effective discrimination strategy by decay curve analysis which would not require the inversion of a physics based model of the data; and

2) What performance would be expected on the small-medium ordnance.

5.4.1 Decay curve analysis and "inversion free" discrimination performance

The feature space plot in Figure 14 and the histogram in Figure 22(b) demonstrate that time decay information provides valuable information for discrimination. The reason for this good discrimination performance is that the time decays of the axial polarization of the 75mm and 3.8" shrapnel rounds are slower than that of the majority of the scrap (Figure 23). From this polarizability plot the slightly different time decay behavior of the 75mm and 3.8" rounds are evident, as is the different decay of a smaller variant of the 75mm round that was used for seeding. When an ordnance item is excited by an EMI sensor, the secondary response that is measured by the sensor is a linear combination of the axial and transverse polarizabilities. Stated another way, the time decay is a linear combination of the time decays along the axial and transverse directions of the item. If one of the soundings during the cued interrogation procedure predominantly excites the axial polarization, then we could obtain an estimate of the dominant time decay directly from the sounding, without having to do a physics based inversion. In Figure 24 we explore this concept further by plotting early and late time features extracted from the primary polarization in (a) and directly from the data in (b). The feature spaces are almost identical and show that an effective discrimination algorithm could be constructed solely from time decay information obtained from the data. The data based decay rates shown in Figure 24(b) were found by fitting a Pasion-Oldenburg model to each sounding and then searching for the sounding that has the slowest decay (defined as the ratio of the twentieth to the first time-channel). We found that a better estimate of the decay rate can be found by fitting the parametric model to the sounding *before* calculating the decay rate. Two decay features were derived from the parametric decay: early time, $d(t_5)/d(t_1)$ and late time, $d(t_{20})/d(t_5)$. Channel t_1 is centered at 0.18ms, channel t_5 and 0.29ms and channel t_{20} at 7ms after transmitter turn-off. Note that we've found that these calculated decay rates are more discriminatory than the Pasion-Oldenburg β and γ parameters (which typically show greater variation for a given object due to the trade-offs between the two parameters).

To obtain a good estimate of the decay rate of the primary polarization requires that one of the soundings predominantly excites the axial polarization. In Figure 25 we investigate just how many of the 55 points in the original template are required. The results show that a good estimate can be obtained by keeping 7 points around the center of the template. With just one point, there

are cases where there is very little excitation of the axial polarization, which results in a low estimate for the primary polarization time decay.

(a) Normalized primary polarizations (b) Normalized secondary polarizations

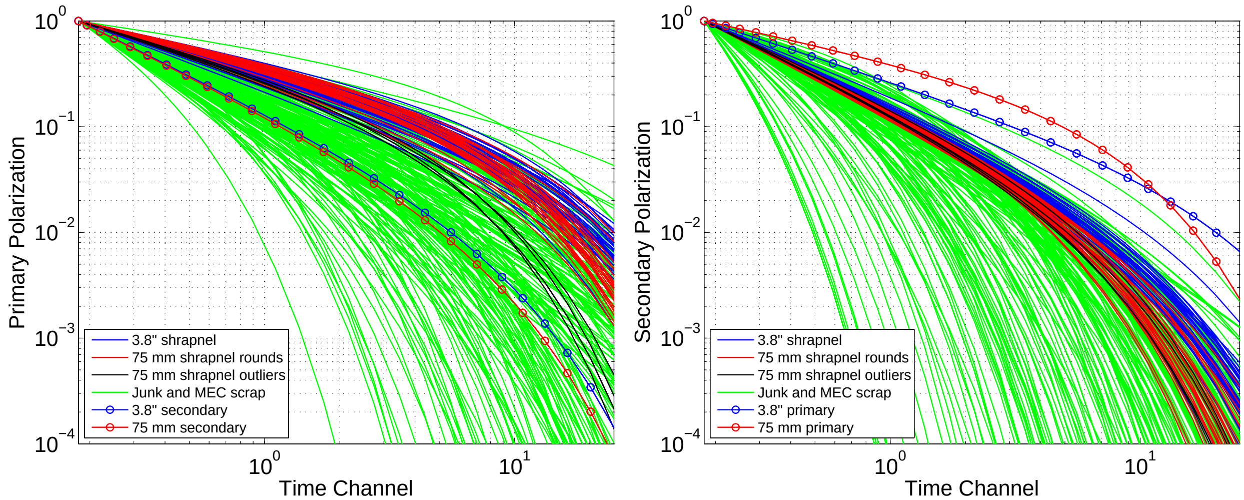


Figure 23. Recovered (a) primary and (b) secondary polarizations of 75mm and 3.8" shrapnel rounds compared to everything else. Note that there are four outliers in the 75mm shrapnel data which comprise a seed item with a slightly different size and shape to the main variant of the 75mm shrapnel round found at the site.

(a) Feature vectors from physics based model (b) Feature vectors from decay curve analysis

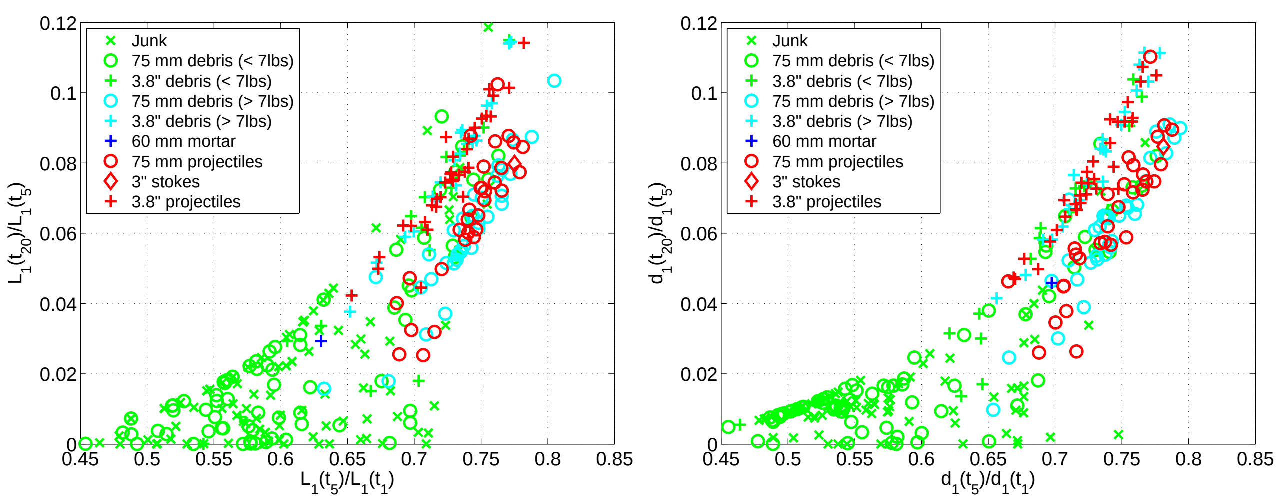


Figure 24. Comparison of time decay parameter feature spaces obtained from (a) inversion of a physics based model; and (b) from decay curve analysis.

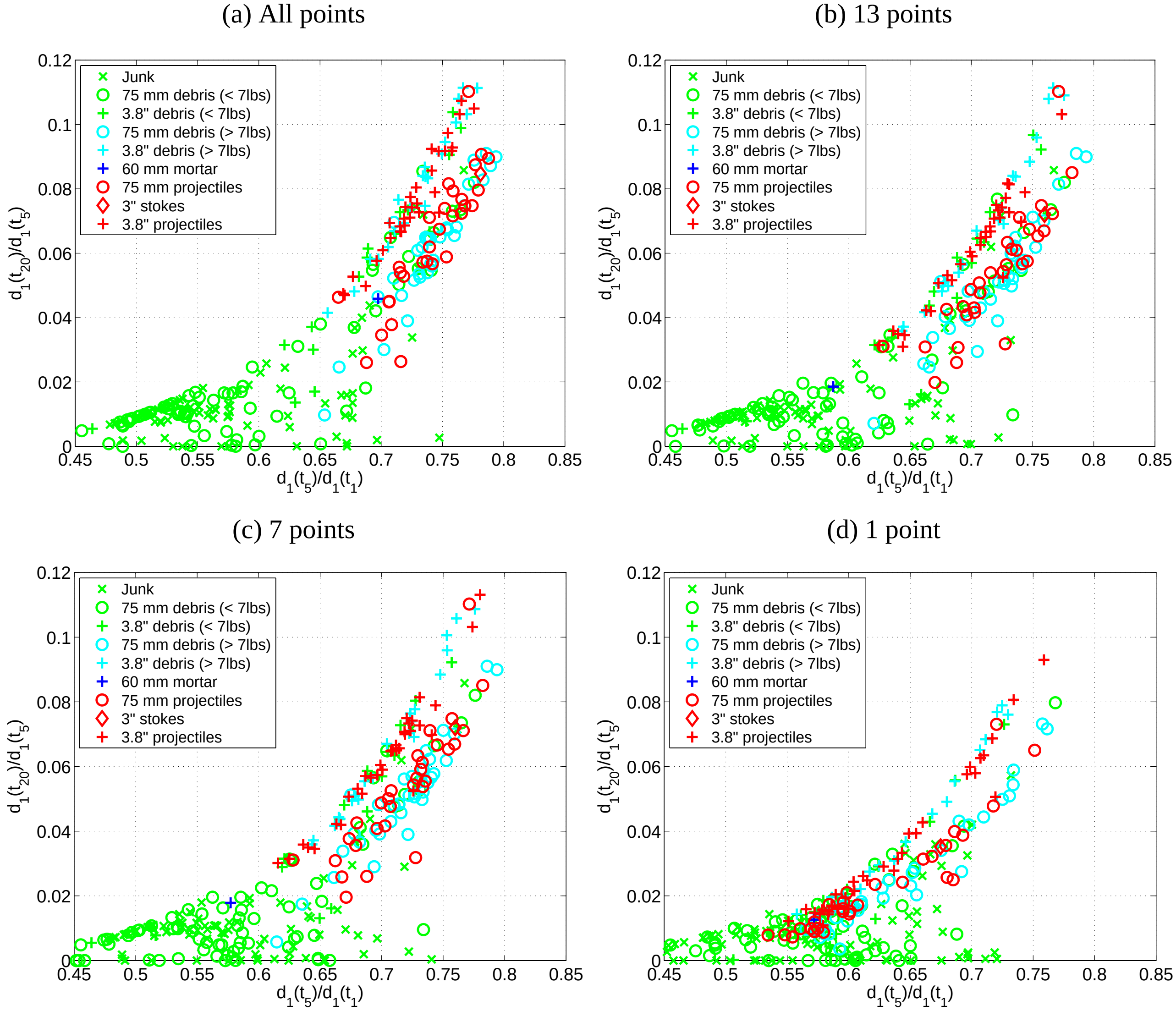


Figure 25. Comparison of time decay features obtained from decay curve analysis of (a) All 55 points on the template; (b) 13 points around the template center; (c) 7 points around the template center; and (d) 1 point corresponding to the anomaly maximum.

Using the early and late time feature vectors obtained from the 7-point decay curve analysis we trained a quadratic discriminant analysis classifier on the same training data set as the physics based classifier. There were no “can’t analyze” anomalies declared as there was no need to fit a model that relies on the spatial integrity of the data. ROC curves for the original physics based model (from Figure 15) and the decay curve analysis are shown in Figure 26. If the “can’t analyze” anomalies from the physics based model are dug-first, then the decay curve method appears to significantly outperform the physics based method. If the “can’t analyze” anomalies are dug after the stop-digging point for the high confidence TOI items, then the discrimination performance of the two methods is comparable. All TOI are recovered at a lower-false alarm rate for the decay curve method because there are 32 false alarms in the “can’t analyze” category for the physics based method.

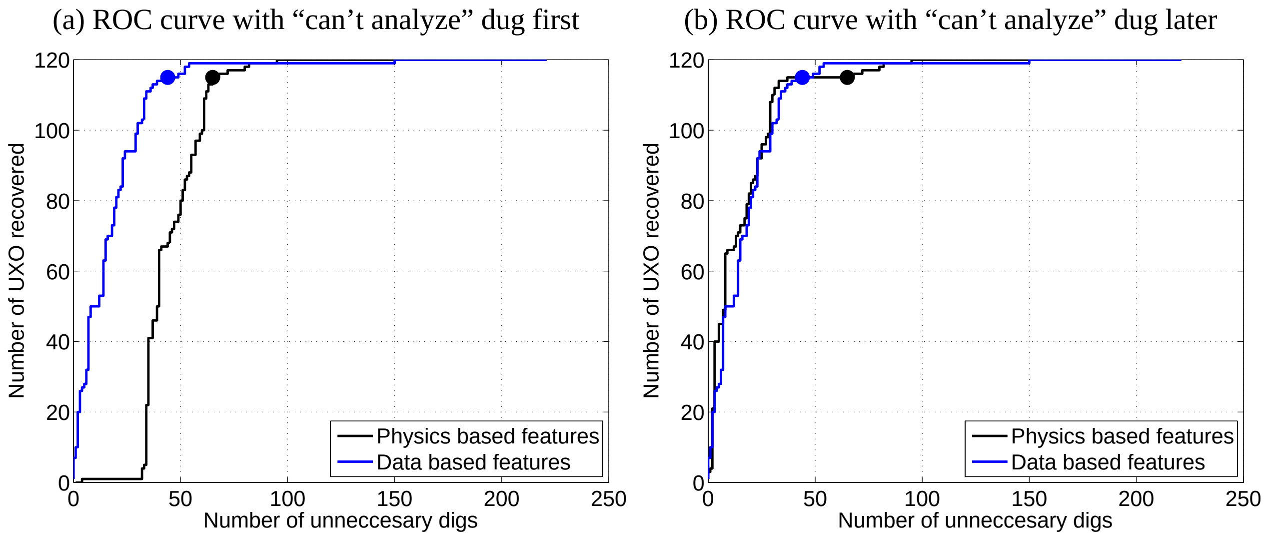


Figure 26. ROC curves for quadratic discriminant classifiers applied to physics based (size and time decay) and data based (early and late time) feature vectors. In (a) the "can't analyze" anomalies are listed first, while in (b) they are listed after the stop-digging point.

We next endeavor to determine what "late time" advantage the EM63 (0.18 to 25 ms) provides relative to the EM61 (0.26 to 1.2 ms). Figure 27 compares a histogram of EM61 time-channel 4 (1.2 ms) over 1 (0.26 ms) and EM63 time-channel 20 (8 ms) over 1 (0.18 ms). The one 75mm TOI with a fast-decay rate in the EM63 is item 5 which we believe has incorrect ground truth. The discrimination information in the two data sets is comparable with 131 (EM61) compared to 139 (EM63) non-TOI with decays faster than the fastest decaying TOI. Thus, for the medium caliber ordnance, we conclude that the later measurement time of the EM63 results in only a small improvement in discrimination ability.

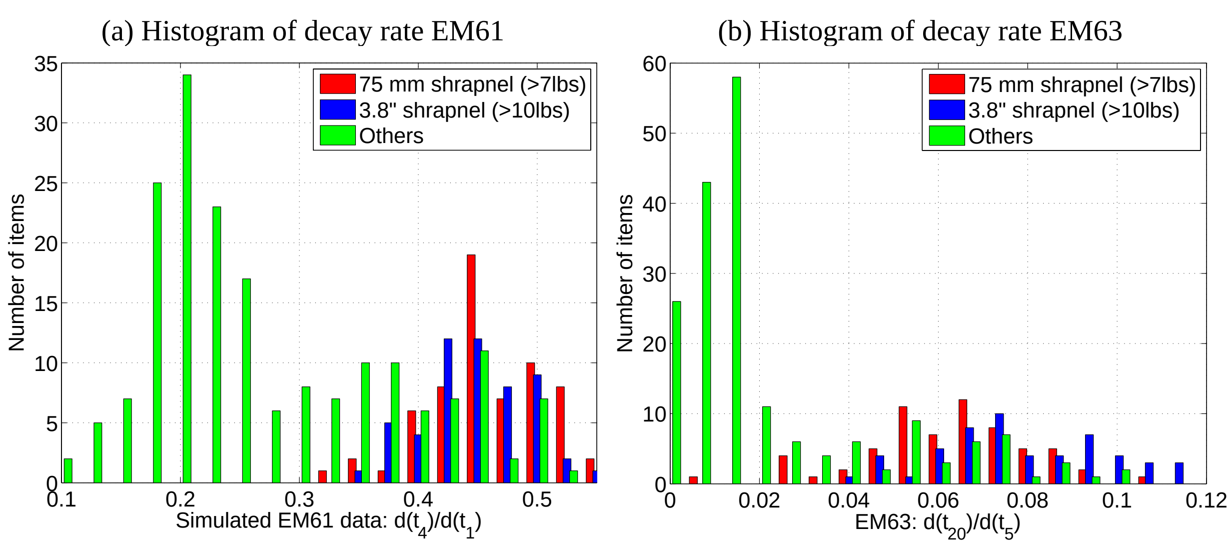


Figure 27. Histogram of decay rates obtained from decay curve analysis of (a) EM61 equivalent data; and (b) late time EM63 data.

5.4.2 Performance expectations on small-medium ordnance

In Figure 28, we plot the normalized primary polarizations for all 37mm projectiles and 60mm mortars and show some feature space plots that could be used for discrimination. Discrimination performance would be poor if we were to use a feature space comprising a size and time decay based feature: the 37mm projectiles and 60mm mortars tend to have small size and relatively fast decay and hence can't be separated easily from the smaller shrapnel and junk. A feature space comprising early and late time decay estimates would provide improved performance (note the 37mm outlier in the physics based decay rate estimate). Most of the discriminatory information appears to lie in the early time decay rate, with 101 out of 217 non-TOI having an early time decay rate smaller than 0.56. In conclusion, we would expect the EM61 to perform comparably to the EM63 on discrimination of small-medium ordnance at this site.

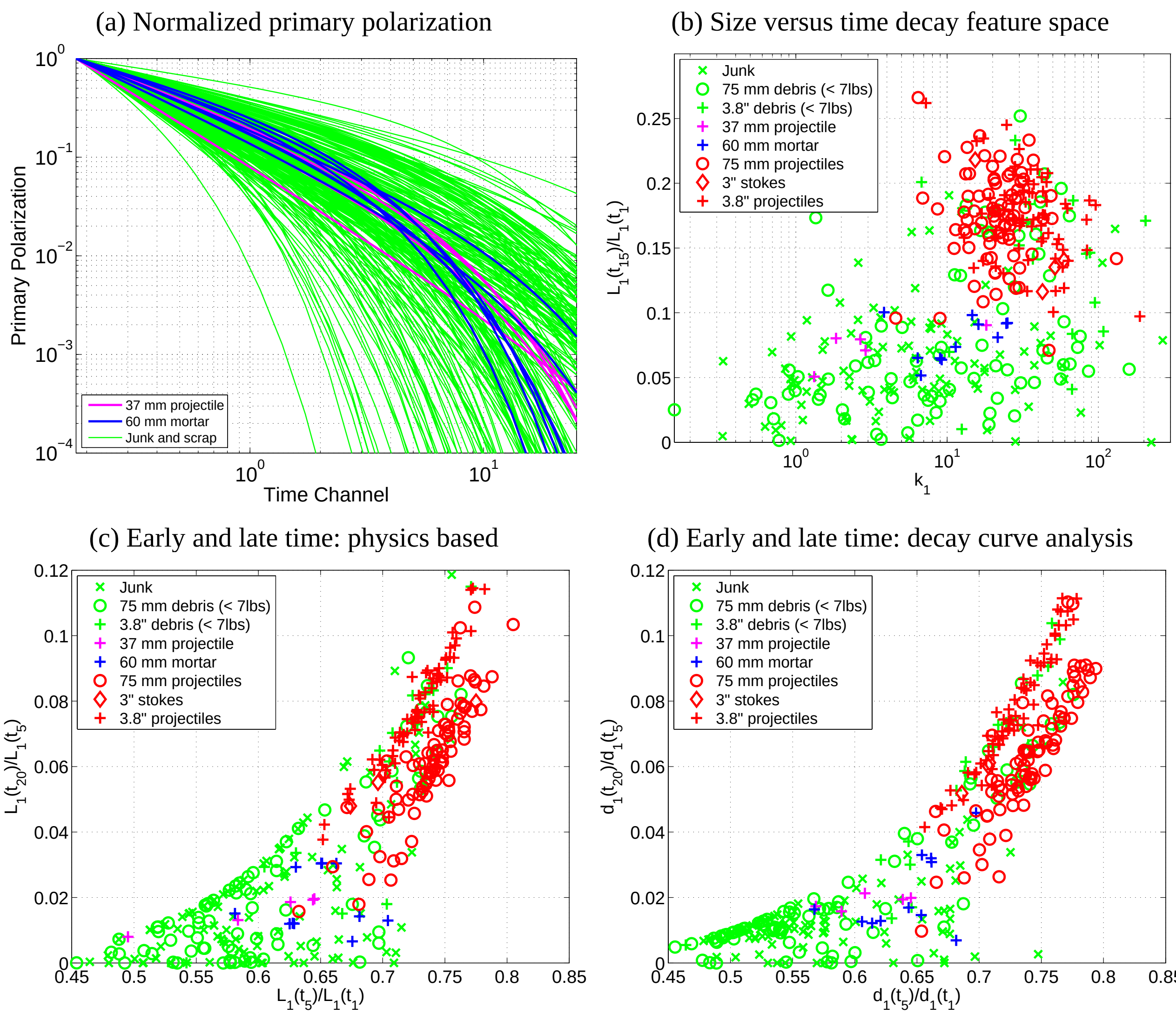


Figure 28. Features for discrimination of 37mm projectiles and 60mm mortars from non-TOI at Fort McClellan: (a) Normalized primary polarizations obtained from inversion of the physics based model; and feature spaces comprising size versus time decay (b), early and late time from physics based (c) and early and late time from decay curve analysis (d).

6 Cost Assessment

Table 9 presents the costs for preparation, data collection, processing, and analysis for the Ft. McClellan demonstration. The costs to deploy the EM-63 cued-interrogation system to Ft. McClellan and perform the data processing included the following:

1) Pre-deployment testing conducted in Ashland, OR;
2) EM-63 shipping (the sensor was government furnished equipment);
3) No field preparation costs were incurred as this was addressed by the site manager;
4) Mobilization and demobilization costs;
5) Two field technicians were supplied by NAEVA, so although no costs were directly incurred by Sky Research, for purposes of reporting the complete cost of data collection we have estimated labor and per diem travel costs for geo-technicians;
6) 401 anomalies were surveyed over a period of 16 days. The total duration of the deployment was 30 days, due to equipment problems.
7) The costs for processing and analyzing the data reflect a greater level of effort than would be projected for subsequent deployments because of the development time required for the feature extraction and classification. We made some adjustments to the underlying inversion methods and trialed a number of different inversion strategies (e.g., noise-levels, masks etc) before settling on our final approach;
8) All costs are fully burdened.

Table 10 presents the cost per anomaly to collect, process, and analyze the data for the 401 anomalies surveyed.

For estimating the costs (fully burdened) to deploy this system to other sites (Table 11), we made the following assumptions:

1) Costs for preparing a site-specific work plan are assumed to be less than that for the Ft. McClellan effort because the effort would be planned and executed as a production survey rather than a technology demonstration.
2) Mobilization/demobilization
    a. The survey requires a 1200 mile mobilization from Denver (assumes a site in southeastern USA);
    b. Mobilization includes 1 day preparation, 1day travel, 1 day set-up on site and 1 day for a test plot survey (and associated processing) for 1 field geophysicist and 2 geo-technicians;
    c. Demobilization includes 1 day of packing up on site and 1 day of organization back at home base.
3) 400 anomalies will be measured, 25 anomalies per day, (16 days to complete data collection, plus weekends)

Table 9. Ft. McClellan Demonstration Cost Summary

Cost Element	Description	Costs
Demonstration Plan	• Draft and final versions • 154 hours	• $15,613
Pre-Deployment Testing	• 182 hours • Field testing equipment, prepare template, preliminary classification/discrimination algorithm development	• $20,476
Instrument costs	• Equipment costs • Consumables and repairs	• Government provided EM-63 • $2,885
Mobilization and demobilization	• Equipment shipping costs (equipment, multiple sensors shipped due to malfunctions) • Equipment packing and shipping, mobilize to site (labor, travel (SKY staff only) • Derived from demonstration costs	• $4,925 • $9,035
Site preparation	No unique requirements encountered	No costs incurred
Survey costs	• 300 hours SKY geophysicist, 16 hours SKY staff remote support (includes hotel and per diem costs) • Estimated NAEVA field personnel support (400 hours labor, 2 people, 20 days per diem)	• $41,380 • $38,000
Data processing costs	• Processing Geophysicists – 260 hours • Senior geophysicists, development and QC – 34 hours	• $31,036
Discrimination and Classification	• 38 hours senior geophysicist	• $4,375
Demonstration Report	• 222 hours geo-physicists, PI, technical edit, cost analysis	• $19,200
Total Demonstration Costs	• Actual and estimated costs for field support	• $186,925

Table 10. Per Anomaly Cost Breakdown

Cost Element	**Cost per Anomaly**
1. Data Collection (based on SKY actual costs plus estimated Nova support costs)	$198
2. Data Processing	$78
3. Discrimination and Classification	$11
Collection, Processing, Discrimination and Classification per Anomaly Costs (sum of items 1 through 3)	***$287***
Complete per Anomaly Costs (including pre-deployment testing, work plan and report preparation – total demonstration costs/400 anomalies)	$467

4) Daily rates are fully burdened and assume 10 hour workdays;
5) Processing requires a Geophysicist II level analyst while interpretation and QC is performed at the Geophysicist V level;
6) Per-diem and hotel are assumed to total $150 per person per-day, with 1.4 days of per-diem/hotel per day in the field (5 day week, 2 days on the weekend), vehicles (assumed 1 rental vehicle required);
7) Equipment charge includes all equipment, consumables and supplies;
8) There is a cost of approximately 15% for report preparation, administration, and reporting support;

Table 11. Future Deployment Cost Estimates

Cost Element	Description	Costs
Pre-Deployment Planning and Work Plan	• Site coordination and logistics • Site-specific work plan	$9,130
Mobilization and Demobilization	• Equipment shipping costs ($1,000) • Field team travel to and from the location, 1 day setup, 1 day test plot survey, 1 day packing/shipping upon survey completion	$16,897
Site Preparation	• Assume site manager will address	No costs incurred
Survey Costs	• Field geophysicist and 2 geo-technicians • 400 anomalies, 25 anomalies per day • 16 days data collection • Field team per diem, including weekends	$60,118
Data Processing and Analysis Costs	• Processing - Geophysicist II, QC – Geophysicist V (assumed level of effort 5% of processing) • **20 minutes per anomaly**	$11,294
	• Processing - Geophysicist II, QC – Geophysicist V (assumed level of effort 5% of processing) • **10 minutes per anomaly**	$5,639
	• Processing - Geophysicist II, QC – Geophysicist V (assumed level of effort 5% of processing) • **5 minutes per anomaly**	$2,897
Demonstration Report	• Reporting and support	$19,200
Total Estimated Demonstration Costs	• Total costs, assuming 20 minutes per anomaly • 10 minutes/anomaly • 5 minutes/anomaly	$116,639 $110,984 $108,242

The projected costs for future deployments are substantially less than the actual costs to conduct the Ft. McClellan data collection and analysis. The lower costs reflect assumptions that there would be fewer days in the field required to address equipment issues (this extended the Ft. McClellan field demonstration by more than a week), and the fact that there was a more significant effort required to develop the appropriate data processing and discrimination approaches. We assume that the lessons-learned from this effort will benefit future deployments and reduce the overall costs to perform similar surveys.

7 Conclusions

In this demonstration, we tested the performance of the Geonics EM63 when deployed in a cued interrogation mode in a heavily wooded section of the Fort McClellan site. A wide range of munitions of different calibers were present on the site including grenades, 37mm projectiles, 60mm mortars, 75mm shrapnel and 3.8” shrapnel rounds. Except for one 37mm and a number of 60mm seed items, all munitions encountered at the site were 75mm or 3.8” shrapnel rounds.

The EM63 surveys were cued off production mode EM61 data collected by NAEVA on behalf of Matrix Environmental, the incumbent contractor at the site. The site surveyed was heavily forested which precluded the use of traditional positional techniques such as Global Positioning Systems and Robotic Total Station. A template constructed from a sturdy pool liner was used instead. The template was centered over each anomaly and data were then collected at 55 pre-marked station locations distributed about the center of the template. During the sixteen field days spent at the site, a total of 401 anomalies were surveyed. This translates to an average of 25 locations per day, which is a relatively slow rate of data acquisition.

Polarization tensor models were fit to each surveyed anomaly. Ground truth information from 60 of the 401 live-site anomalies, along with 18 items in the Geophysical Prove-out and 21 items measured in a test-pit were available to train a statistical classifier. Features related to shape, which are encapsulated in the relative values of the primary, secondary and tertiary polarizations, were unstable and could not be used for reliable discrimination. A feature space comprising the size and the relative decay rate of the primary polarization was found to be effective for discrimination of the medium caliber projectiles (75mm and 3.8” shrapnel). All demonstration metrics related to discrimination of these medium caliber projectiles were met. At the operating point, all but 5 of 119 targets of interest were recommended for excavation, with 34 false alarms. If the operating point was relaxed slightly then all medium caliber projectiles would have been recovered with 51 false alarms.

Retrospective analysis revealed that excellent discrimination performance could have been obtained by using a feature space comprising an early and late time feature extracted from the object’s primary polarization. Furthermore, we found that these feature vectors could be approximated without fitting polarization tensor models to the data, and by using just seven measurement locations around the template center. These approximate early and late time decay features were extracted from the sounding with the slowest decay (defined as the ratio of the 20th to 1st time-channels).

The discrimination challenge was more difficult when the smaller munitions (37mm and 60mm caliber) were included. Due to the low number of items in the test data, it was not possible to determine the discrimination performance on the small-medium ordnance. Retrospective analysis suggested that an early time decay estimate could have been used to recover all 37 and 60mm caliber ordnance while eliminating approximately 101 of 217 false-positives.

For both the small (37 and 60mm caliber) and medium (75mm and 3.8” caliber) items, we found that an early time decay rate, equivalent to one that could be obtained with an EM61, provided almost as much discrimination potential as the late time decay rate. These observations are consistent with the experience of Keiswetter (2007) at the Lake Success Business Park site where decay rate information is used as a first past discriminant. The slow rate of data acquisition and the fact that decay curve analysis was as good or better than inversion for a physics based model, leads us to conclude that the benefit of the extra information extracted from the EM63 is not justified by the increased data collection, processing and interpretation costs. The results demonstrate that some level of discrimination can be obtained without complex inversion and statistical classification, and with instrumentation as simple as an EM61. This conclusion does not imply that better instrumentation or rigorous inversion and statistical classification would not provide an advantage. With better instrumentation and/or data quality we would expect to be able to use a richer variety of feature vectors (e.g. the relative values of the primary, secondary and tertiary polarizations) and thus would expect significantly improved discrimination ability.

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9 Points of Contact

Table 12. Points of Contact

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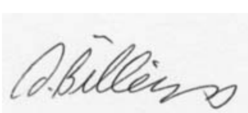

Stephen Billings
March 18, 2009

Appendix A: Quality Assurance Project Plan

A.1 Purpose and Scope of the Plan

The purpose of this plan is to outline the quality assurance procedures for this project.

A.2 Quality Assurance Responsibilities

The QA Officer for this demonstration will be Dr Stephen Billings of Sky Research. Dr Billings is a geophysicist with over 8 years experience with QA of geophysical data. He will oversee the demonstration, assure compliance with the demonstration plan, and attest to the results.

A.3 Data Quality Parameters

The following calibration/standardization tests are performed at least once each day:

<u>Static background calibration and spike test</u>

For the EM63, a static background and spike test is performed twice daily, prior to collecting data and after completion of data collection. This test monitors the instrument background readings, monitors for electronic drift, identifies potential interference, and determines the repeatability of measurements over a standard test item. The standard test item is a wire loop with about a 10cm diameter.

With the instrument on a plastic saw horse at an elevation of a least 1.5 meters above ground a background measurement is recorded for a period of one minute (Figure A-1). A standard test item is then placed under the center of the coil and an additional minute of data is recorded. The test item is removed and an additional one minute of background data is collected.

Readings for the response of the standard test item should be within 20% after subtraction of the sensor baseline response.

The full static-spike-static test is conducted at the start and end of each day. A static background check will be conducted after surveying each anomaly (i.e. where the EM63 will be placed on the plastic saw-horses and data collected for 30 seconds).

Figure A- 1. EM63 cart on sawhorses for static background test at the Ashland Test Plot.

A.4 Calibration Procedures, Quality Control Checks, and Corrective Action

The following procedures and logs are used to maximize standardization, repeatability, and control of mapping activities:

- Calibration (as per previous section) – The sensor will be field-tested daily to ensure that it is operating properly.
- Data Processing Log - All data from the field are run through a standard data processing procedure. This procedure is the same for all data and is tracked with the Data Processing Log. This log documents all coordinate transformations, visual data quality checks, statistical data quality checks, survey coverage statistics, interpolation parameters, etc.
- Field Activity Log - This log is filled out by the project geophysicist and details all activities of the survey. This is a daily log and contains observations about crew performance, sensor performance, site conditions, and weather changes.
- Equipment Verification Log - This log documents the daily calibration of each field instrument. Daily calibration procedures are executed for each geophysical and navigational instrument (see previous section).
- Data Control Log - This log tracks all data flowing in from the field and out of the office. Data include all geophysical field data, sensor verification data (via Equipment Verification Logs), and all field notes from Field Activity Logs.
- Data Analysis Log - All data reduction, processing and analysis steps are documented through this form. Each log is checked by the project geophysicist for completeness and adherence to pre-defined procedures.

A.5 Calculation of Data Quality Indicators

Data quality indicators will be computed directly from the performance metrics and goals established in the Demonstration Plan. As described above, these metrics will be incorporated into the metadata for each data set, and will become an established permanent element of each.

A.6 Performance and System Audits

All project activity will be reviewed on an ongoing basis by the QA Officer and included in a weekly QA status report. Performance and system audits will be implemented on an irregular basis by the Principal Investigator to assure that the procedures specified in this QA/QC plan are being implemented.

A.7 Quality Assurance Reports

The QA Officer will provide weekly quality assurance reports as described above, and produce a final QA report upon completion of field activities.

A.8 Data Format

Most data collected during this demonstration will be in digital format stored using industry standard ASCII protocols.

A.9 Data Storage and Archiving Procedures

Data collected during this demonstration will be archived at Sky Research's office in Ashland, Oregon. Nightly backups are performed on the servers that will be used to store the data.

APPENDIX B: CALIBRATIONS, DATA PROCESSING AND ARCHIVING

B.1 Initial Quality Control

Each night an initial QC of the data was conducted by the QA officer to determine if there were any problems with the data that would require any anomalies to be recollected. A detailed list of the QC results is provided in Appendix E and a brief summary is presented in Table B1 below.

Table B1. Summary of QC issues by day.

Day	QC summary
March 17, 2008	No significant QC issues
March 18, 2008	No significant QC issues
March 19, 2008	Data corrupt for the final few points of N072E144_41, need to recollect
March 20, 2008	Data corrupt from start of day, current varying wildly. No targets collected
March 24, 2008	N072E143_5, amplitudes inexplicably dropped, need to recollect.
March 26, 2008	N072E143_18, target not centered, need to recollect
March 27, 2008	N071E141_2, target not centered, need to recollect
March 28, 2008	In air static measurements a fraction of previous values, Data collected over previously target prior to changes in static calibration values appears repeatable
March 29, 2008	No significant QC issues
March 31, 2008	N071E145_5 collected twice by mistake, ignore first pass over target, second pass looks to be centered better.
April 1, 2008	No significant QC issues
April 2, 2008	N073E144_10, das stopped recording, final points spread over different file sets
April 3, 2008	No significant QC issues
April 4, 2008	No significant QC issues
April 5, 2008	N072E147_7 recollected on April 7
April 7, 2008	No significant QC issues
April 8, 2008	N078E144_3 target not centered, need to recollect
April 9, 2008	No significant QC issues
April 10, 2008	No significant QC issues
April 11, 2008	N078E147_21, points missing from SEN file, recollect
April 12, 2008	No significant QC issues
April 14, 2008	No significant QC issues
April 15, 2008	No significant QC issues
April 16, 2008	No significant QC issues

B.2 Daily Calibrations

A summary of the daily calibration results is provided in Table B2. Figures B2 and B3 plot the amplitudes of the daily static-spike-spike-static tests for March 29 to April 16, 2008. The two spike items, a small steel sphere of radius 2.5cm and a 75mm shrapnel round from the McClellan site are shown in Figure B1. After the second week of surveying a second spike item was added to the in air measurements because of the initial difficulties with encountering variable spike measurement values on multiple systems in the first weeks of surveying (see description in

Section 5). A second and more substantial spike test item was included to confirm that EM63 amplitudes were maintaining stability and scaled appropriately for varying target sizes.

Table B2. Summary of Daily Calibration Results.

Day	Measurement	steel sphere spike t1 - static t1	75mm spike t1 - static t1
d08078 (March 18)	start of day calibration	679.968982	
d08079 (March 19)	start of day calibration	598.099404	
d08080 (March 20)	start of day calibration	-24292.42158	
d08084 (March 24)	start of day calibration	560.39125	
	end of day calibration	91.100502	
d08086 (March 26)	start of day calibration	509.814249	
	before first em63 battery change	487.372695	
	after first em63 battery change	544.330506	
	end of day calibration	566.13729	
d08087 (March 27)	start of day calibration	660.510395	
	before first em63 battery change	566.928693	
	after first em63 battery change	603.007831	
	before second em63 battery change	553.378446	
	after second em63 battery change	556.339299	
	before third em63 battery change	503.080643	
	after third em63 battery change	551.616683	
	end of day calibration	520.014538	
d08088 (March 28)	start of day calibration	28.632999	
	before first em63 battery change	27.879796	
	after first em63 battery change	30.72069	
	end of day calibration	29.428937	
d08089 (March 29)	start of day calibration	29.380824	405.449563
	before first em63 battery change	26.879051	436.4281
	after first em63 battery change	28.735736	426.391745
	before second em63 battery change	27.931976	432.289314
	after second em63 battery change	27.753918	427.012085
	before third em63 battery change	26.737529	426.541034
	after third em63	28.016293	423.161323

Day	Measurement	steel sphere spike t1 - static t1	75mm spike t1 - static t1
	battery change		
	end of day calibration	27.535327	430.634134
d08091 (March 31)	start of day calibration	27.69556	440.050266
	before first em63 battery change	28.094634	431.070991
	after first em63 battery change	27.748147	453.336875
	before second em63 battery change	29.378611	432.763652
	after second em63 battery change	27.324784	433.636941
	before third em63 battery change	26.49384	421.864028
	after third em63 battery change	29.448281	428.770457
	end of day calibration	28.466429	435.542748
d08092 (April 1)	start of day calibration	29.994124	461.471501
	before first em63 battery change	27.732241	428.279905
	after first em63 battery change	30.930478	453.947556
	before second em63 battery change	29.607681	440.606974
	after second em63 battery change	26.035489	444.994297
	end of day calibration	27.918539	439.331742
d08093 (April 2)	start of day calibration	29.97212	442.931426
	before first em63 battery change	28.004419	444.883878
	after first em63 battery change	28.772296	451.38363
	before second em63 battery change	28.097847	430.966217
	after second em63 battery change	28.957705	450.652791
	end of day calibration	26.196522	415.787266
d08094 (April 3)	start of day calibration	31.429805	468.112748
	before first em63 battery change	27.152228	417.536105
	after first em63 battery change	29.077151	437.761729
	before second em63 battery change	28.393009	431.073987
	after second em63 battery change	28.727229	455.280216
	end of day calibration	29.149594	447.006287
d08095 (April 4)	start of day calibration	30.360978	438.456559

Day	Measurement	steel sphere spike t1 - static t1	75mm spike t1 - static t1
	before first em63 battery change	28.730125	429.831718
	after first em63 battery change	28.700622	445.154019
	end of day calibration	26.157188	424.48818
d08096 (April 5)	start of day calibration	31.053878	462.42213
	before first em63 battery change	28.825654	454.425456
	after first em63 battery change	31.581371	459.73231
	before second em63 battery change	31.434671	452.907733
	after second em63 battery change	28.257366	444.624047
	end of day calibration	30.153497	462.254438
d08098 (April 7)	start of day calibration	31.61382	474.333787
	before first em63 battery change	29.177268	457.180181
	after first em63 battery change	31.133342	449.87598
	before second em63 battery change	23.377581	462.715785
	after second em63 battery change	29.027832	453.404008
	end of day calibration	27.987831	433.241561
d08099 (April 8)	start of day calibration	29.781009	450.192431
	before first em63 battery change	28.648291	456.74331
	after first em63 battery change	31.265367	443.82706
	before second em63 battery change	28.493787	441.109387
	after second em63 battery change	28.74985	458.916077
	end of day calibration	30.839098	447.658386
d08100 (April 9)	start of day calibration	30.229445	464.295727
	before first em63 battery change	27.901711	439.317414
	after first em63 battery change	29.118172	451.629957
	before second em63 battery change	32.175028	437.915269
	after second em63 battery change	29.590055	459.589963
	end of day calibration	30.972657	449.172827
d08101 (April 10)	start of day calibration	28.460784	426.597428
	before first em63 battery change	27.058127	413.965379

Day	Measurement	steel sphere spike t1 - static t1	75mm spike t1 - static t1
	after first em63 battery change	28.499904	438.219566
	before second em63 battery change	27.761981	424.984135
	after second em63 battery change	27.36247	435.249663
	end of day calibration	28.474536	434.913066
d08102 (April 11)	start of day calibration	28.007405	434.284196
	before first em63 battery change	27.592316	431.117877
	after first em63 battery change	27.20816	428.32177
	before second em63 battery change	25.476811	391.146838
	after second em63 battery change	29.832122	441.915198
	end of day calibration	26.946741	425.750087
d08103 (April 12)	start of day calibration	30.046833	439.029827
	before first em63 battery change	27.510674	429.929347
	after first em63 battery change	29.318434	443.321853
	end of day calibration	29.399924	438.91665
d08105 (April 14)	start of day calibration	28.870866	459.469755
	before first em63 battery change	30.531337	447.712712
	after first em63 battery change	26.603491	420.08548
	before second em63 battery change	29.207904	446.372264
	after second em63 battery change	28.166571	446.044943
	end of day calibration	27.166112	424.116184
d08106 (April 15)	start of day calibration	31.321102	467.395174
	before first em63 battery change	24.199575	443.667079
	after first em63 battery change	31.062585	457.533767
	before second em63 battery change	28.911885	444.835575
	after second em63 battery change	30.526734	466.945322
	end of day calibration	28.787336	439.5006
d08107 (April 16)	start of day calibration	30.387336	454.270171
	before first em63 battery change	29.871902	428.507513
	after first em63 battery change	30.077036	442.669008

Day	Measurement	steel sphere spike t1 - static t1	75mm spike t1 - static t1
	before second em63 battery change	27.474003	411.934602
	after second em63 battery change	29.418957	438.693729
	end of day calibration	27.995303	414.968209

Figure B1. Daily calibrations were performed with a steel sphere (left) and a 75mm inert target from the McClellan site (right). The steel sphere was of radius 5cm while the 75mm target had a length of 21.3cm.

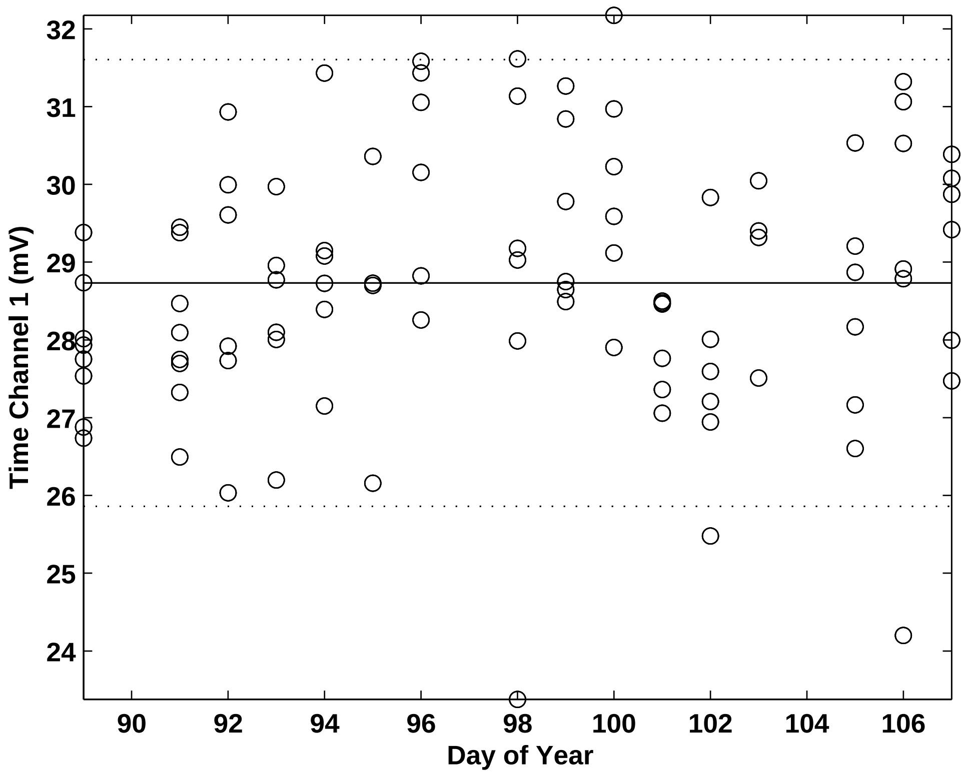

Figure B2. Daily calibrations with a steel sphere and the EM63 elevated on a saw-horse. The median of the calibrations is shown as a solid black line, with +- 10% of the median shown as dashed lines. All except 4 of the 96 calibrations are within 10% of the median value.

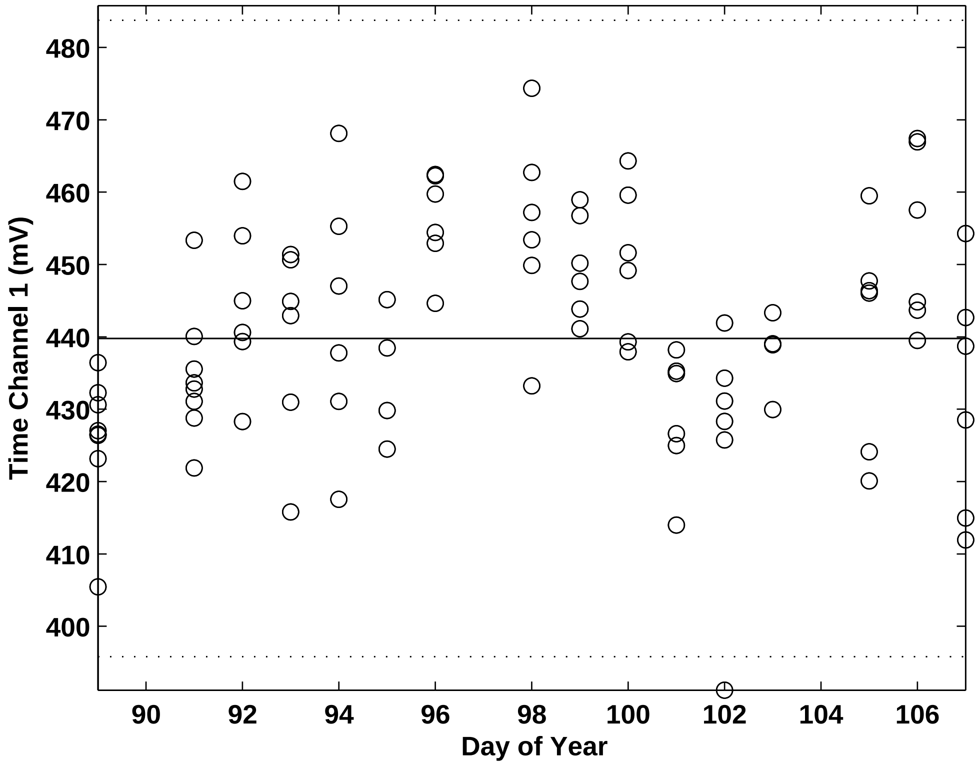

Figure B3. Daily calibrations using a Ft. McClellan 75mm inert UXO with the EM63 elevated on a saw-horse. The median of the calibrations is shown as a solid black line, with +- 10% of the median shown as dashed lines. All except 1 of the 96 calibrations are within 10% of the median value.

APPENDIX C: DAILY ACTIVITY LOG

Monday, March 17 (d08077)

- On site: Kingdon , Russ Dobler (NAEVA), Dieter Loew (NAEVA)
- Windy in the morning, pleasant in the afternoon.
- Get to base around 06:20, quick check in with Penny Johnson and Kevin Hagie from NAEVA, Kent Boler/Richard Satkin from Matrix. Toured GPO and areas already reacquired from tract 2B. GPO is very inhospitable, large grade. Numerous trees on both GPO and tract 2B.
- Slow day, CSM replacement EM63 didn't arrive until mid day. Head to electronics store to get USB cable to connect serial port hub to toughbook.
- COM port on CSM logger was missing both screws to hold it in place. Sounded like one had come loose inside the logger. Opened the logger and replaced the screw. Need to get similar screw to replace other missing screw on COM port #1.
- Assembled EM63, charged batteries, labeled templates and collected some data in the parking lot near the end of the day.
- Need to go to store to purchase inverter, bungee cords, wing nuts to secure tilt meter to instrument shelf.
- Keep working till 5:00PM.
- Fiddle with scripts in the evening to import data into UXOLab. Had conflicting versions on laptop. Took a while to sort out

Tuesday, March 18 (d08078)

- On site: Kingdon , Russ Dobler (NAEVA), Dieter Loew (NAEVA)
- Arrived on site for 6:30am safety meeting, packed up and headed out to survey location
- Managed to collect data over nine flagged targets. When broke for lunch and switching out batteries, Russ felt he might need to go to the hospital, was feeling aches and pains that couldn't continue surveying. Decided to quit for the day and get him checked out.
- Left site around 2pm.

Wednesday, March 19 (d08079)

- On site: Kingdon , Russ Dobler (NAEVA), Dieter Loew (NAEVA)
- Arrived on site for 6:30am safety meeting, packed up and headed out to survey location
- Managed to collect data over five flagged targets before the rain set in. Heavy rain early in the morning, covered up electronics on instrument shelf with a garbage bag. When rain continued to come down, placed a tarp over the system. Eventually decided to shut down data acquisition for the day when it appeared the rain wouldn't let up.
- Left site around 2pm.

Thursday, March 20 (d08080)

- Data was corrupt from first measurements of the day, current seemed to be drifting widely and even registered negative values occasionally. Contacted Geonics, they recommended switching cables (already tried), battery (also attempted) and finally suggested that the console needed to be returned for repair. As Friday was a holiday, they wouldn't receive the system until Monday meaning that it was unlikely that we could get it back until the middle of the following week. At that point contacted Ryan North to request a loan of the USACE EM63 for the interim. Shipped the console overnight to Geonics via FedEx

Friday, March 21 (d08081)

- No data collection, waiting for loaner system from USACE to arrive. Commercial invoice missing, KK drives to Gadsden to correct the paperwork and get the console on its way to Geonics.

Saturday, March 22 (d08082)

- USACE equipment arrived at KK hotel, NAEVA truck came to hotel and loaded equipment to transport to the site. Arrived on site 12pm. Unpacked console from shipment, no power, manual indicated that it takes overnight to charge. Brought logger and charger back to hotel to make sure console charges. Went into the field and relabeled templates so that the numbering scheme represents the 4 corners for background measurement. Left the site at 2:30pm.

Sunday, March 23 (d08083)

- Site closed for Easter.

Monday, March 24 (d08084)

- On site: Kingdon, Dobler, Loew

- Kingdon arrives on site at 6:30, picks up spare pro4000 batteries and fast charger as recommended by Ryan North. Return to hotel and put batteries on charge, after 2 hours, there is enough power to turn on data logger. Contacted Juniper for advice on how to check the internal battery status.

- Contact Dobler/Loew, decide to mobilize to site and attempt additional data collection with USACE console being used in conjunction with the CSM system and cables.

- Arrived at site at 11am, packed equipment and headed to field. Had to stop surveying and move out of defined exclusion zone for blowing in place of HE items, delayed approximately 1 hour. Returned to survey area and continued data collection over 2 targets. Data initially looked good however on the third target (which was highest amplitude of the 3 targets surveyed), amplitudes inexplicably dropped and there was virtually no response from the target visible on the data logger.

- Packed up and headed back to equipment shop to run tests by replacing cables to attempt to narrow down the source of the problem. Unsuccessful, amplitudes remain low.

- Will assemble complete USACE system tomorrow and try running with orange battery and contact Geonics if problems persist.

- Todd Meglich (sp?) from CSM called to enquire about the problems that we've encountered with the EM63, told him about the current values jumping all over and the data values spiking at 5000mV across all time-channels. Also informed him that the console had been returned to Geonics for repair. He asked that we keep him apprised of the status when we hear back from Geonics.

Tuesday, March 25 (d08085)

- On site: Kingdon, Loew

- Arrived on site 6:30am

- Russ Dobler spent the night in hospital with bronchitis and took the day off to rest. Alex Costera from NAEVA will be replacing him for two days (Thursday/Friday) when he takes a vacation planned prior to learning of his McClellan deployment.

- Assembled the USACE system (coils, console, cables, preamp). In order to avoid unpacking second USACE box, used CSM orange batteries, backpack and push handle

(since instrument shelf was fastened to the CSM handle). NEED TO MAKE SURE THAT THESE SYSTEMS COMPONENTS DO NOT GET MIXED UP.

- Packed up gear and went to field site. Collected in air static-spike-static measurement and noted that spike once again is only around 100mV. In air measurements at the same location that preceded good quality data collection (i.e. the first calibration yesterday recorded values of ~500mV over the same target, steel sphere of about 5cm diameter.

- Called Geonics and spoke with Vasa, he is currently repairing the CSM console. He found that one of the four zeniths(?) was shorted as was a transistor. He was attempting to repair and ship out today, but they have no coils or other components in house to test. He says the best that he can do is observe on an oscilloscope and make sure everything looks normal there. Gil had advised me to ship only the console since that's where the problem seemed to be.

- Told him the issues with apparent lack of gain in the USACE console. He suggested that it's unlikely to be a cable problem, because that would involve intermittent data rather than a constant stream of data, coils are also very unlikely he thought. Most likely scenario is the preamp box or the console itself. Since we have 3 preamps available, I tested all three with a static-spike-static measurement on the sawhorses. All 3 produced readings of 100mV, well below the spike value that preceded valid data, ~500mV.

- The USACE console was shipped in working order. The initial spike measurement (when it was used with the CSM system) looked good, as did the first 2 targets covered. For unknown reasons, the amplitudes suddenly dropped on the third target yesterday. Those diminished amplitudes continued today.

- My concern is whether the custom cables and voltage regulator that the systems group made could be shorting something out in the console. They didn't have a chance to test because they had to manufacture the cables literally overnight after FedEx lost the NRL system. On the other hand, we have been able to collect some data using the lithium ion batteries with both consoles so they seem functional. It just seems suspicious that two working consoles have experienced problems within such a short time span. Although the issues with the two consoles are unique. CSM console showed current wildly varying and data values spiking around 5000mV. USACE console has stable current but the measurement amplitudes seem under gained. When repaired console is returned, we'll try collecting with orange Geonics batteries only and see how that affects things. If we're able to acquire data without issues, we'll stick with the orange batteries. Will still need to use a lithium ion to power the tilt meter.

- Left site 11:30am. KK called Geonics and spoke with Vasa from the hotel over the afternoon trying to sort out the issues.

- Geonics repaired first (CSM) problem console. Said there were shorted transistors and zeniths(?) inside. Will arrive by 8:30am tomorrow according to the FedEx website.

- Tried to ship complete system with problem console to Geonics for testing. FedEx would not accept the shipment, said coil box was too large. Strange since 3 of them arrived by FedEx delivery in identical boxes…

Wednesday, March 26 (d08086)

- On site: Kingdon, Loew, Dobler
- Geonics repaired CSM console arrived via FedEx in the am and met onsite at 10am in order to test and resume data collection.
- Assembled the full CSM system (now using the orange EM63 lead acid battery packs shipped with the system rather than the lithium ion batteries), ran test is the shop parking plot to confirm that neither the drifting current nor the diminished amplitude problems were still occurring. In air measurements of sphere confirmed values were comparable to measurements made when the system was functioning properly. Headed out to the field to make measurements.
- Had to wait for a demo shot before getting access to the site, approximately one hour.
- In air measurements in the field also agreed well with previous data. Continued surveying over flagged targets.
- Collected data in N072E143 over 11 targets in approximately 4 hours. Finally some forward momentum.
- Left the site at 5pm

Thursday, March 27 (d08087)

- On site: Kingdon, Loew, Alex Kostera
- Arrived on site at 6:30am
- Fairly productive day surveying, no equipment issues, good progress. Only delay was
- had to leave the survey area for a demo shot for approximately one hour.
- A few issues with the record keeping, one photo was missing, need to reinforce attention to detail for the person setting up templates and recording order of data acquisition.
- A few software DAS improvements. It would be easier to create file tracking spreadsheets if the file sets were automatically output to the log file every time that a begin/end survey event takes place that was the user entered “target 4” would match nicely with the corresponding file set. The EM63 values need to be updated on screen

more frequently (when using 3 second time measurements, often there are no values that show up on screen for a given point). There is a bug in the numbering of fiducial points that automatically are entered in the log file (ending point listed starts at point 0 and ends at last point-1).

- Collected data over 23 targets
- Left site at 5pm

Friday, March 28 (d08088)

- On site: Kingdon, Loew, Kostera
- Arrived on site at 6:30am
- Packed equipment, headed out to the field. Found that in air static spike measurements were reading only 40mV, a fraction of the values recorded yesterday (~500mV). Packed equipment up, drove back to shop to get phone reception to call Geonics and troubleshoot what could be causing the problem. Tried a second set of coils with new cables and also tried replacing the preamp with other 2 preamps that were available. In the parking lot at the shop (smaller sawhorses), actually noticed larger (~1000mV spike measurement) but that was only temporary and when tried a few minutes later with no changes to the setup, values were ~100mV. Problem seems to be intermittent with the gains being applied. Noted that there was detectable responses observed when placing the steel sphere under the coils, even if it is a much lower amplitude than the day before. Out of desperation as much as anything else, decided to collect data over a higher amplitude (based on EM61MKII picked values) buried target from the previous day to compare how amplitudes compared. Amplitudes seemed similar so decided to keep surveying to observe if a range of target amplitudes hold.
- Began surveying around 11am
- Collected data over 15 targets in total
- Left site at 5pm

Saturday, March 29 (d08089)

- On site: Kingdon, Loew, Kostera
- Arrived on site at 6:30am

- Packed equipment, headed out to the field. Found that in air static spike measurements were still reading only 40mV, a fraction of the values recorded previously (~500mV). Brought out a second spike target, this time a 75mm UXO from the McClellan site and found that this more substantial target produced spike values on the order of ~400mV. Continued collecting data over buried targets. Revisited earlier grids and collected some larger amplitude targets that were accessible but excluded from the original target picks for one reason or another. Need to be careful with battery management, have a total of 3 em63 batteries, need to put first battery back on charge immediately after it's drained to ensure that have enough power for a full day of surveying. Laptop batteries also need to be put on charge as soon as they are drained.

- Collected data over 25 targets in total

- Left site at 4:15pm

Sunday, March 30 (d08090)

- Day off, no one on site.

- KK corresponding with Gil from Geonics to discuss issues of varying spike measurements. Sent him g63 files which should indicate.

- Updating files on the shares, making corrections to some of the file tracking files.

- Updating progress spreadsheet, printing out additional target lists and maps.

Monday, March 31 (d08091)

- Arrived on site at 6:30am

- On site: Kingdon, Loew, Dobler

- Things progressed nicely. Only problem was the juniper logger battery died after only 6 hours. Managed to borrow a spare battery from NAEVA that we can use for the duration of the em63 measurements. Had about an hour of downtime retrieving battery and replacing.
- Should be good for rest of that we'll always have a spare fully charged.

- Some inconsistencies with the record keeping, one target was not captured, forgot the camera on site, need to check photos tomorrow to confirm. Also need to stress how important careful record keeping is for target identification. Makes the file tracking a big hassle when things aren't consistent between field notes on PC and hand written notes on maps.

- Noticed that many of the targets with picked values of <10mV had no detectable change of amplitudes on the EM63 so stopped collecting data over these smaller targets. Also noticed that many of the flags were not coincident with the maximum target response as observed on the EM63 logger. Made appoint of taking the time to find maximum target response and move template to center over maximum response. Takes a bit more time but less than time than having to recollect a target too far off the template center.

- Collected data over 24 targets.

- Left site at 5pm.

Tuesday, April 1 (d08092)

- Arrived on site 6:30am

- On site: Kingdon, Loew, Dobler

- A bit of a slow start to the day. Forgot battery cable for em63 backpack, had to drive back to storage area and retrieve. Juniper data logger battery after only one target. Replaced with a loaner battery from NAEVA and ran fine for the rest of the day. Need to check if the external power supply is not charging the juniper battery properly. Have a 2nd backup battery from NAEVA and a charger, so will always try to have a fully charged (using external charger battery) so that we don’t have to stop collecting data because the juniper battery dies.

- Had to move location twice once started on the east side of Iron Mtn. Rd. but then ran out of targets. Had to wait for demo shot to complete then move back over to the west side.

- Penny will have NAEVA flag the GPO sometime tomorrow. It might be a good place to collect during the Mon-Thurs period when there seems to be more demo shot delays. It should not be in the exclusion zone and would permit continuous work. Might make more sense to come back to the down range on Friday/Saturday when there are less interruptions.

- Had a flat tire on the truck to end the day.

- Collected data over 16 targets

- Left the site at 5pm.

Wednesday, April 2 (d08093)

- Arrived on site 6:30am

- On site: Kingdon, Loew, Dobler

- Fairly productive day, no issues with equipment or demo shots today, about as productive as we can expect for the site. Collected total of 25 targets. EM63 batteries (3, 2CSM, 1 USACE) lasted the whole day as did the juniper battery. Laptop batteries are not an issue, can charge using inverter as they are drained and always have one ready to go.

- QC-ing the data, some issues with the software DAS not completing a few points in a SEN file. Need to keep an eye on this, also noticed this happening in the field once. Do not want to get back from field and find data not recording properly. KK checking through the day to make sure SEN files are being created. Also need to keep an eye on the software DAS front end on the toughbook, have noticed that although the light does not turn from green to red (indicating data not being received), the symptom seems to be the "Waiting For New Line" appearing in the EM63 data window but no data values following. Need to ask Systems to increase the rate at which EM63 data is displayed, at the current rate, for 3 second recording intervals, sometimes the data does update during the measurement interval.

- Left site at 4:45pm

Thursday, April 3 (d08094)

- Arrived on site 6:30am

- On site: Kingdon, Loew, Dobler

- Collected data over flagged items on the GPO. It was literally on the side of a hill with most locations having a meter difference in elevation from one side of the template to the other. We started off realizing that there was no way to keep the template even remotely centered so we hammered some plastic stakes through the corners of the template. That held the template nicely in place but smooth plastic surface on a steep slope doesn't fare well for keeping cart or cart pushers stationary.

- We managed to collect data over 18 targets. That was all that were accessible with the template of the 30 odd targets listed in the attached ground truth table. Tore down equipment and moved templates and sawhorses back to survey grids in preparation for the next day's surveying.

- Left site at 4:30

Friday, April 4 (d08095)

- Arrived on site 6:30am
- On site: Kingdon, Loew, Dobler
- Productive day, managed to collect data over 23 targets by 2pm. Unfortunately that's all that we were able to collect as a tornado warning occurred at that point, ending the day early.
- Left site at 3:30

Saturday, April 5 (d08096)

- Arrived on site 6:30am
- On site: Kingdon, Loew, Dobler
- Miserable day at the start, fairly heavy rains left over from tornados the day before, but cleared up after a couple of hours and remained overcast for the remainder of the day
- Productive day, managed to collect data over 27 targets. Had collected over 28 targets in total but one was a recollect because the target was not properly centered under the template before surveying.
- Left site at 4:30

Monday, April 7 (d08098)

- Arrived on site 6:30am
- On site: Kingdon, Loew, Dobler
- Raining in the morning, but cleared up after a couple of hours and remained overcast for most of the remainder of the day, sun came out near end of day
- Productive day, managed to collect data over 26 targets.
- Left site at 4:45

Tuesday, April 8 (d08099)

- Arrived on site 6:30am
- On site: Kingdon, Loew, Dobler

- Clear day, cool in the morning and sunny in the afternoon.
- Chose a set of typical ordnance for the McClellan site to make pit measurements.
- Productive day, managed to collect data over 28 targets.
- Left site at 4:45

Wednesday, April 9 (d08100)

- Arrived on site 6:30am
- On site: Kingdon, Loew, Dobler
- Clear day, cool in the morning and sunny in the afternoon.
- Productive day, managed to collect data over 29 targets.
- Left site at 4:45

Thursday, April 10 (d08101)

- Arrived on site 6:30am
- On site: Kingdon, Loew, Dobler
- Clear day, cool in the morning and sunny in the afternoon.
- A bit of a sluggish day, had to set up in 2 different grid locations, collected 26 targets.
- Left site at 4:45

Friday, April 11 (d08102)

- Arrived on site 6:30am
- On site: Kingdon, Loew, Dobler
- Overcast, dark clouds kept rolling in an out, forecast was for severe thunderstorms and hail but we managed to get in nearly a full day’s surveying.

- A decent day, had to set up in 2 different grid locations, target were much more plentiful in the second set of grids. Managed to collect 24 targets in a slightly weather shortened day.

- Finished a bit early, weather warnings and imminent rain had us packing up early.

- KK went to Lowes to get small piece of plywood to cover pits for measurements tomorrow and a metric measuring tape for depths.

- Left site at 4:15

Saturday, April 12 (d08103)

- Arrived on site 7:00am

- On site: Kingdon, Loew

- Down to a 2 person crew for the next 2 days.

- Cool and cloudy in the morning and sunny in the afternoon.

- Dug 2 pits (1 shallow, 1 deep) and collected data over 7 typical items from the site at 3 different orientations (vertical, 45 degrees, horizontal) for all items)

- Left site at 2:45

Monday, April 14 (d08105)

- Arrived on site 6:30am

- On site: Kingdon, Loew

- Down to a 2 person crew. Picked the most target dense grids. A bit of confusion as the grids weren't completely reacquired, a reac team was scheduled to work in the area. Managed to get them to start from a different location, keeping separate by at least 100ft to avoid any possibility of interference. A lot of starting and stopping as had to move templates after each 2 target set was measured.

- Collected data over 21 targets

- Cold, light rain throughout the day, small hail for a short period

- Left site at 5:00

Tuesday, April 15 (d08106)

- Arrived on site 6:30am
- On site: Kingdon, Loew, Brian
- Back to a 3 person crew. A bit slow getting started as had to spend some time explaining to Brian the different roles. He seems like a quick learner and picked everything up quickly. A reac team was scheduled to work in the area. Managed to keep at least 100ft to avoid any possibility of interference. Had to stop for 45 minutes for a demo shot in the area.
- Collected data over 25 targets
- Cold and sunny in the morning, warmer in the afternoon.
- Left site at 5:00

Wednesday, April 16 (d08107)

- Arrived on site 6:30am
- On site: Kingdon, Loew, Brian
- A NAEVA reac team was scheduled to work in the area. Managed to keep at least 100ft to avoid any possibility of interference.
- Collected data over 25 targets. Headed back to storage area around 3:30 to begin disassembling and packing equipment.
- Sunny and warm in the morning and afternoon.
- Left site at 5:00

Thursday, April 17

- Arrived on site 6:30am
- On site: Kingdon, Loew, Brian
- Finished disassembling and packing equipment.
- Left site at 10:30am

APPENDIX D: ISSUES FACED DURING THE INITIAL WEEK

All equipment had been shipped to the Ft. McClellan site two weeks prior to the planned start of field measurements. Days before the crew was preparing to mobilize to the site, it was discovered that FedEx had lost a critical portion of the shipment. The EM63 case containing the data console, cart wheels, custom cables, and batteries was misplaced. FedEx indicated that they had no information on the whereabouts of the missing case and that it could be weeks before it turned up in their lost and found. In order to maintain the planned schedule, an additional EM63 was required. Geonics was contacted but they had no systems available in their rental pool. At this point the Colorado School of Mines (CSM) was contacted and they agreed to loan Sky Research their system for the ESTCP demonstration work at Ft. McClellan.

The scheduled start date for EM63 surveying was Monday March 17, 2008. The CSM system did not arrive until later in the afternoon so much of the first day was spent assembling the system and no actually targets were surveyed. The first day of surveying was March 18, 2008. Nine targets were surveyed before a NAEVA crew member indicated that he was feeling severe pains and surveying was halted for the day as the crew member went to the hospital to get checked out. On the second day of surveying (March 19) only 5 targets were acquired using the cued surveying template before heavy rains set in. Electronics were covered with garbage bags and a tarp but after rain persisted, shut down for the day without collecting any additional targets.

On March 20, the data was corrupt from the start of day calibration. The reported current viewed on the EM63 data logger was erratic and the measured voltages were entirely inconsistent with previous calibrations. The manufacturer (Geonics) was contacted for advice. The portion of the original shipment that did arrive allowed a second set of coils to be assembled and the preamp swapped out but problems persisted, indicating that the issue was likely related to the component for which there was no spare (due to the lost FedEx shipment), the EM63 console. The console was opened and examined for loose connections but everything was fine. Geonics indicated that the console would need to be shipped back to Canada for inspection and repair. Because the following day was a holiday in Canada followed by a weekend, they would not have a chance to examine the system for 4 days.

In an attempt to keep field efforts moving forward, the US Army Crops of Engineers (USACE) was contacted and they agreed to loan one of their EM63 systems to Sky for the ESTCP demonstration work at Ft. McClellan. The USACE system arrived on March 22nd however the batteries needed to be charged so the first day of attempted surveying with the USACE equipment was Monday March 24, 2008. Because the problem was isolated to the CSM console, rather than assembling the full USACE system, the console from the USACE was connected to the CSM cart and surveying continued with this combined setup.

On Monday March 24, the combined EM63 system was taken to the field The initial calibration measurements were in agreement with those seen prior to the erratic measurements observed while using the CSM console that was sent back for repairs. The first two targets surveyed produced data that was in agreement with the relative amplitudes reported in the EM61 MKII picked values from the full coverage NAEVA surveys used to identify potential cued interrogation targets. However, on the third target of the day, the amplitudes inexplicably dropped and there was virtually no target response detectable on the EM63 console data logger.

This was especially troubling because the third target was picked with a significantly higher amplitude than the first two targets (which produced reasonable and detectable responses). Attempts were made to swap out cables, components and coils but the amplitudes measured when calibrating with the EM63 in air on sawhorses over the steel calibration sphere continued to be a small fraction of the values previously observed (91mV versus 562mV).

The following day (March 25, 2008), we contacted Geonics to discuss the sudden drop in amplitudes observed on the USACE console. They suggested that the problem was unlikely to be a cable issue because that would involve intermittent data rather than a constant stream of data that was being observed. They suggested that the symptoms indicated the issue would most likely a problem with either the preamp or the console itself. We again tried replacing all 3 available preamps with no change in the observed diminished amplitudes, indicating that again the issue appeared to be with the EM63 console. The concern at this point was whether the custom cables and voltage regulator built by Sky to permit powering with light lithium ion batteries could be damaging the consoles. This seemed unlikely as similar cable had been fabricated and tested without issues at the Ashland test plot. However, the components in use had to be manufactured in a rush without any opportunity to fully test once FedEx lost the portion of the initial shipment that contained the pre-built and tested cabling. The decision was made to revert to the heavier Geonics standard issue lead acid batteries once the repaired CSM console arrived in order to remove the possibility of the custom cabling as a source of issues with the consoles. The lithium ion and custom cabling would still be required to power the inclinometer.

On March 26, the repaired CSM console arrived. According to the Geonics technician, a couple of transistors within the console were shorted out and needed to be replaced. The in air measurements agreed well with the previous measurements and surveying over flagged targets resumed. Over the course of March 26-27 data was collected over 34 flagged targets.

On March 28, The start of day calibrations again produced amplitude values that were a fraction of those previously observed. The steel sphere which had previously registered values of approximately 550mV was now registering values of approximately 29mV. The large discrepancy indicates that one of these two values was clearly incorrect. Initially it was believed that the 29mV values were the problematic values since the amplitudes previously recorded were always substantially higher (i.e. > 500mV). However, data collected for a similar sized item a similar sensor height on the USACE test stand in Vicksburg, MI produced EM63 values for the first time-channel of 27.5mV which were more in line with the 29mV readings. The manufacturer was contacted and they had no reasons why such variations would occur other than an intermittent problem. An intermittent problem also seems unlikely as the amplitudes remained above 500mV until March 28 after which point it remained steady at approximately 29mV.

In spite of the diminished amplitudes observed with the CSM console beginning on March 28, a distinct and repeatable (albeit smaller) spike response was evident in the in air measurements. A second, more substantial spike target (75mm shrapnel round from the McClellan site) was included in the in air measurements to confirm that an elevated response was obtained for the larger target with respect to the smaller steel calibration sphere. This second spike target was included in all calibrations and pre/post battery change measurements in order to provide additional diagnostics of EM63 performance. The 75mm round did indeed produce amplitudes considerably higher than those observed for the steel sphere. A median value of approximately 440mV was observed for 75mm target for all of the final sixteen days of surveying as illustrated

in Figure B3. Although the cause for the diminished amplitudes is not well understood, it was encouraging that the spike targets of varying sizes produced amplitudes that scaled appropriately with the target size. In a further attempt to confirm that the EM63 was recording valid data, one of the higher amplitude targets collected before the diminished amplitudes occurred was resurveyed the following day to gauge if the recorded target response was repeatable in light of the substantially varied in air measurements on the consecutive days.

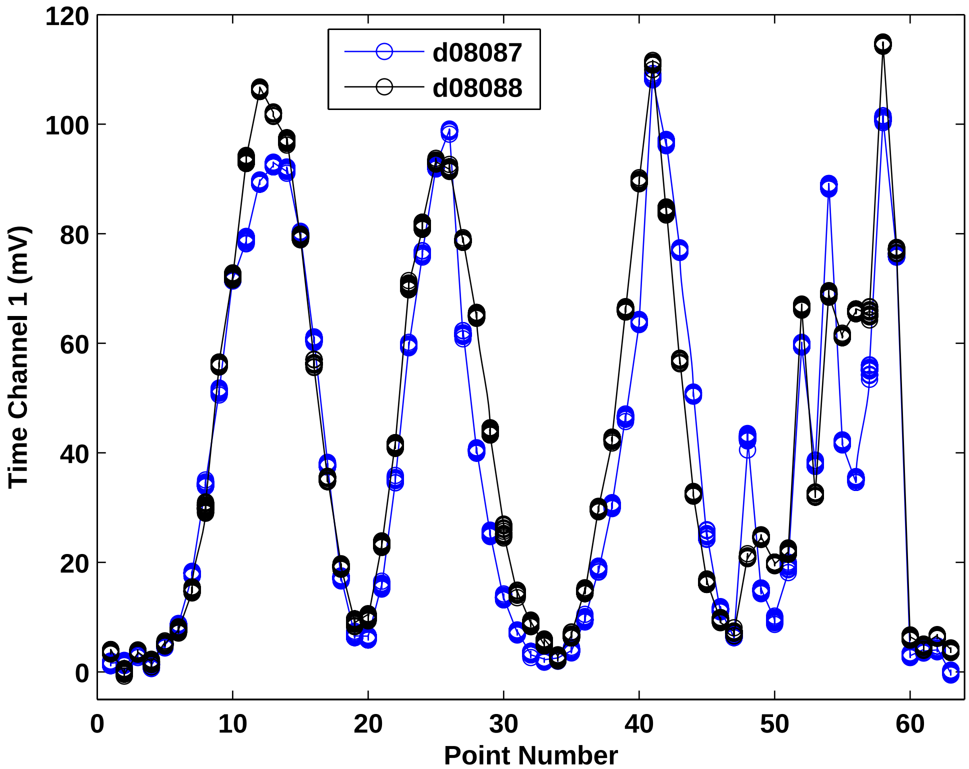

Figure D1. Repeated measurements over the same target, N071E141_2 on consecutive days. On the first day (d08087), in air calibration measurements produced values of approximately 550mV. The following day (d08088) produced in air calibration measurements of approximately 29mV.

In spite of the fact that the in air measurements diverged substantially on the consecutive survey days, the repeated data collected over target N071E141_2 and shown in Figure D1 indicates that the EM63 data collected over a given buried target did not vary significantly. While template was centered over the same flagged target on the consecutive days, it would not have been placed in the exact same location so some variations are expected between the respective points. All 63 points collected on the template are plotted in Figure D1 for both survey days. At each template location, multiple EM63 readings are taken and the mean value is typically assigned to the template point. All of the multiple readings at each template point are plotted in Figure D1 for comparison sake. The measured amplitudes over N071E141_2 produce similar amplitudes for days prior to and after the diminished amplitudes were observed.

Unfortunately, there was not more than one target which was surveyed twice with the EM63 both before and after the calibration amplitudes dropped. To further investigate the entire collection of field targets acquired using the EM63, we compared the maximum amplitudes for each target for both the EM63 and the NAEVA EM61 target picks. The relationship between the EM61 and

EM63 would not, in general be linear since the data is a gradient measurement in the EM63 and a single coil measurement for the EM61. The goal of plotting the EM61 vs. the EM63 results against each other is to see if there are two distinct groups of points following different relationships which would indicate series of measurements where the sensor is not working properly. Consider the plot shown in Figure D2 which illustrates responses for all the field targets surveyed (this does not include test pit or GPO measurements). The NAEVA picked EM61 values are plotted against the maximum values for the Sky EM63 data. Results for the first 47 targets, when multiple changes in the calibration amplitudes were observed are plotted as red circles. The remainder of targets are indicated as black plus sign symbols. A line of best fit is shown for both sets of targets in the respective color. A line of best fit was also plotted for the entire data set in blue however it was coincident with the black best fit line for targets 47-400 and is therefore not discernable in the plot. The cluster of red circles in the bottom left corner of the plot is a consequence of choosing to survey over targets with picked amplitudes of < 10mV in the first few days before deciding to focus on higher amplitude targets where possible. While the plots are biased by the early exploration of low amplitude anomalies, that is more a "strategy" issue as opposed to an instrumentation issue. The plot of Figure D2 does indicate that the relationship between the EM61 and EM63 measurements is fairly consistent as there does not appear to be a substantive instrumentation difference between the first few days and the remainder of the survey.

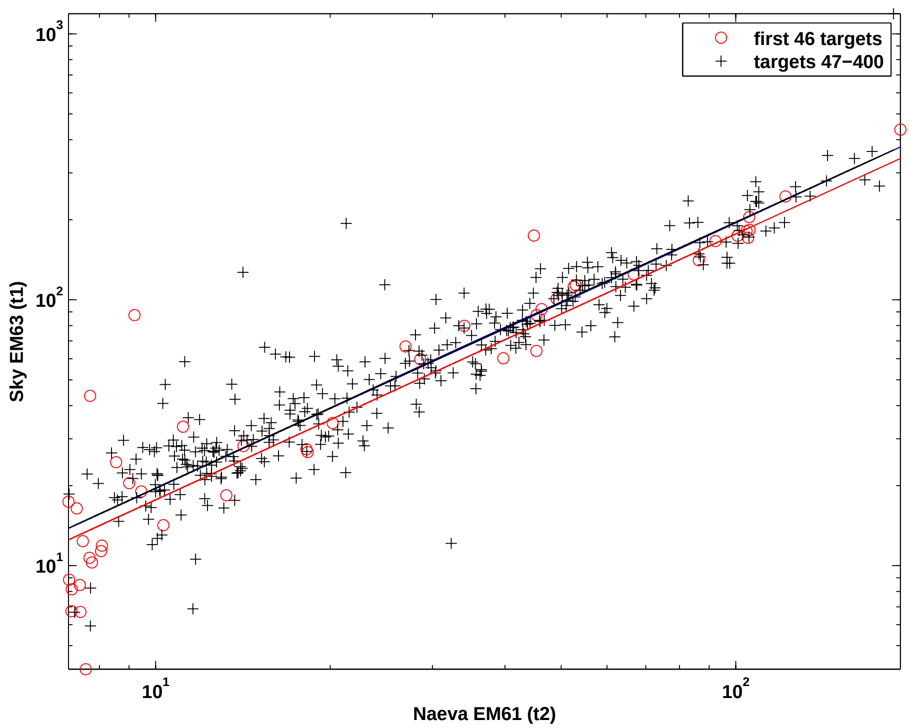

Figure D2. EM61 versus EM63 measurements for the entire set of Ft. McClellan field targets. EM61 data was the second time-channel target picks supplied from NAEVA while the EM63 data represents the maximum value in the first time-channel over each target.

There are four main points that summarize the EM63 data acquired at Ft. McClellan:

1. Amplitudes remained relatively invariant for both spike items (sphere, 75mm) from March 28-April 16 over which time 397 targets were surveyed (including 41 GPO and pit measurements).
2. Amplitudes remained somewhat invariant for the steel sphere spike measurements from March 18-27 over which time 50 targets were surveyed.
3. Amplitudes remained consistent over the repeated target N071E141_2 in spite of the variations in the in air measurements on those days. Data collected over a range of picked amplitude targets also resulted in EM63 data that with corresponding amplitudes over the respective targets
4. Amplitudes from test stand measurements are in agreement with the diminished amplitudes discussed in point 1.

Based on the above findings, we are confident the majority of the items collected over the time period of March 28-April 16 are comprised of high quality EM63 data. We do have some reservations about the targets acquired over the time period of March 18-27 which corresponded with the higher amplitude in air measurements over spike targets. However, in part because of the consistency of the repeated data over target N071E141_2 (See Figure D1) and in part because a review of the data collected over the time period of March 18-27 indicates reasonable amplitudes with no obvious data quality issues, we also intend to invert the data from the targets acquired during the March 18-27 timeframe. If analysis of inversion results produces any additional insight into potential data quality issues with the initial batch of targets, we will exclude those from further analysis.

The repairs of the two consoles were for unique issues. The first CSM repair involved shorted out transistors while the USACE console had to have its AD converter replaced.

APPENDIX E: FILE TRACKING SPREADSHEET AND INITIAL QC OF DATA

Survey Event	Grid	Target	Comment	Cart	Logger	Template
March 18 2008			**9 anomalies**			
E020878AA	N072E145	Static-spike-static	on sawhorses, in a region within the grid clear of any targets	Dieter	Kevin	Russ
E020878AB	N072E145	tilt test	right wheel up, left wheel up, pitch forward	Dieter	Kevin	Russ
E020878AC	N072E145	2	recollect point 16 (cart moved during collection)	Dieter	Kevin	Russ
E020878AD	N072E145	13	root underneath template, non level surface. recollect point 56(the repeat of point 1), cart moved during collection)	Dieter	Kevin	Russ
E020878AE	N072E145	10	uneven surface near start (points 1-3), removed indicator for this grid, elevation change at start would snap, eyeballed centering. Points 44, 50 stump tough to get on exact point	Dieter	Kevin	Russ
E020878AF	N072E144	42	entire first line pull em63 rather than push (tree near start, was only way to collect first 5points). other lines pushed	Dieter	Kevin	Russ
E020878AG	N072E144	26		Dieter	Kevin	Russ
E020878AH	N072E144	29	recollect point 3 moving	Dieter	Kevin	Russ
E020878AI	N072E145	in air measureme nt	changing lithium ion and laptop battery, before disconnecting battery	Dieter	Kevin	Russ
E020878AJ	N072E145/ 144	in air measureme nt(145), 39(144)	in air measurement on sawhorses (same location as morning cal), forgot to break the file, includes in air measurement after battery change and target location 39	Dieter	Kevin	Russ
E020878AK	N072E144	4		Dieter	Kevin	Russ
E020878AL	N072E144	25	had to pull (not push cart) for entire first line, pushed remainder. ground depression in center of target location	Dieter	Kevin	Russ
E020878AM	N072E144	19	IGNORE, recollect on points 1, 30 (battery died on point #37, recollect)	Dieter	Kevin	Russ
March 19 2008			**5 anomalies**			
survey event	**grid**	**target**	**comment**	Dieter	Kevin	Russ
E020879AA	N071E143	Static-spike-static	on sawhorses, in a region within the grid clear of any targets	Dieter	Kevin	Russ
E020879AB	N071E143	tilt test	right wheel up, left wheel up, pitch forward	Dieter	Kevin	Russ
E020879AC	N072E144	19	near corner 1, tree in the way measured at a point just off template and went back to same location after surveying the template	Dieter	Kevin	Russ
E020879AD	N072E144	44		Dieter	Kevin	Russ
E020879AE	N072E144	11		Dieter	Kevin	Russ
E020879AF	N072E144	8	target 44 nearby (but not overlapping with template)	Dieter	Kevin	Russ
E020879AG	N072E144	5	near target 48 from adjacent grid, (think it was N071e144?...check position if looks like overlapping signals). Pulled EM63 (rather than push) on line containing points 20-33, first few points on line(20-23) slightly off location because of tree in the way	Dieter	Kevin	Russ
E020879AH	N071E143	in air measureme nt	changing lithium ion and laptop battery, before disconnecting battery	Dieter	Kevin	Russ
E020879AI	N071E143	in air measureme nt	in air measurement using new battery on sawhorses (same location as morning cal), ignore line 1, didn't zero em63, use line 2.	Dieter	Kevin	Russ
E020879AJ	N072E144	41 (IGNORE)	IGNORE, data corrupt for final few points, large and negative. Perhaps related to huge downpour that caused surveying to halt after this anomaly. uneven surface, point 19 slightly off location, tree in the way	Dieter	Kevin	Russ
		notes:	total collection time 2.5 hours, 6 targets….10hours should allow 30-35 targets			

			lithium ion and laptop battery both lasted 2 hours. Will need to always have a laptop battery on charge using inverted (3 batteries x 2 hours = 6 hours). Lithium ions should give 8 hours, but one is faulty. Could also put on charge using inverter. Plus bring backpack and battery for possible end of day use as needed.			
			one of the lithium batteries is faulty. Pack B indicated it is fully charged but no power is delivered to tilt meter or EM63 after Pack A is drained.			
March 20 2008			**0 anomalies**			
E020880AA	N071E143	IGNORE (static – spike-static)	Static-spike-static, values are way out of what (~5000mV…something wrong with the system)	Dieter	Kevin	Russ
E020880AB	N071E143	IGNORE (tilt test)	IGNORE, tilt test, redone in file set AC with instrument zeroed	Dieter	Kevin	Russ
E020880AC	N072E144	IGNORE (41)	only collected first few points on the template, data is obviously corrupted, packed up and went back to shop to investigate further and try switching cables…	Dieter	Kevin	Russ
March 24 2008			**2 anomalies**			
E020884AA	N071E143	IGNORE	no sen file recorded, EM63 wasn't being recorded, had to reset software DAS	Dieter	Kevin	Russ
E020884AB	N071E143	IGNORE	IGNORE, tilt test, redone in file set AC with instrument zeroed	Dieter	Kevin	Russ
E020884AC	N071E143	Static-spike - static	calibration test, in air measurement on sawhorses	Dieter	Kevin	Russ
E020884AD	N071E143	tilt test	right wheel up, left wheel up, pitch forward	Dieter	Kevin	Russ
E020884AE	N072E143	41	uneven surface, large divot near center	Dieter	Kevin	Russ
E020884AF	N072E143	32		Dieter	Kevin	Russ
E020884AG	N072E143	5 (IGNORE …amplitudes too low)	almost no response? target is supposed to be 105mV but previous target was only ~40mV and seemed much stronger on logger screen. Something seems wrong here	Dieter	Kevin	Russ
E020884AH	N071E143	Static-spike-static	recorded values for previous target seemed too low, switched lithium ion battery and switched preamp from CSM to NRL to see if that made a difference. Switched both of these before making the static-spike-static measurement. Probably should have first collected a static-spike-static with system as was for previous target(5) for direct comparison with spike value recorded in file set AC but didn't.	Dieter	Kevin	Russ
		notes:	running with entire CSM system except console which was replaced with ERDC loaner (changed battery and preamp before final static-spike-static)			
March 26 2008			**11 anomalies**			
E020886AA	shop parking lot	Static-spike-static	on shorter sawhorses borrowed from shop, testing no current problems, amplitude gain problems, looks good			
E020886AB	N071E143	Static-spike-static	start of day calibration, on sawhorses at same location used for the past week	Dieter	Kevin	Russ
E020886AC	N071E143	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward	Dieter	Kevin	Russ
E020886AD	N072E143	5		Dieter	Kevin	Russ
E020886AE	N072E143	31	seems to be missing point 31 in sen file	Kevin	Dieter	Russ
E020886AF	N072E143	1	large hole in center, uneven surface	Kevin	Dieter	Russ
E020886AG	N072E143	20		Kevin	Dieter	Russ
E020886AH	N072E143	2	target 21 is one meter from the point 2 corner of the template	Kevin	Dieter	Russ
E020886AI	N072E143	62		Kevin	Dieter	Russ
E020886AJ	N072E143	26	hole in middle, uneven surface. point 33 slightly off. tree in way. laptop battery dies on target 26, had to end survey at point 54, restarted after replacing laptop battery at point 55. Did not change em63 battery yet	Kevin	Dieter	Russ
E020886AK	N072E143	26	points 55-63 of target 26 after replacing laptop battery	Kevin	Dieter	Russ
E020886AL	N071E143	in air measurement	changing orange em63 battery, before disconnecting battery	Kevin	Dieter	Russ

E020886AM	N071E143	in air measurement	changing orange em63 battery, after connecting fresh battery	Kevin	Russ	Russ
E020886AN	N072E143	55		Kevin	Russ	Russ
E020886AO	N072E143	36		Kevin	Russ	Russ
E020886AP	N072E143	6		Kevin	Russ	Russ
E020886AQ	N072E143	18 (IGNORE)	target off center, recollected on d08093	Kevin	Russ	Russ
E020886AR	N071E143	IGNORE	Re-did end of day calibration in the next file set	Kevin	Russ	Russ
E020886AS	N071E143	Static-spike-static	on sawhorses at same location used for the past week	Kevin	Russ	Russ
E020886AT	N071E143	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Russ	Russ
		notes	using the entire CSM system (along with the repaired console from Geonics) today			
			dieter pushed cart for first target, felt really sick, KK pushed for remainder of targets. Russ moved tarps and ran computer at end of day when Dieter couldn't			
March 27 2008			**23 anomalies**			
E020887AA	N071E143	Static-spike-static	start of day calibration, on sawhorses at same location used for the past week	Dieter	Kevin	Alex
E020887AB	N071E143	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward	Dieter	Kevin	Alex
E020887AC	N072E143	44	last target in n072E143	Dieter	Kevin	Alex
E020887AD	N072E142	40	first target in n072E142	Dieter	Kevin	Alex
E020887AE	N072E142	33		Dieter	Kevin	Alex
E020887AF	N072E142	7	three targets just off survey template ((25,27,28) may appear in data). Point 5 slightly off location due to a tree	Dieter	Kevin	Alex
E020887AG	N072E142	4		Dieter	Kevin	Alex
E020887AH	N072E142	3		Dieter	Kevin	Alex
E020887AI	N072E142	8	point 20 slightly off because of tree, point 33 slightly off due to stump	Dieter	Kevin	Alex
E020887AJ	N071E143	Static-spike-static	in air measurement before changing battery (laptop and em63)	Dieter	Kevin	Alex
E020887AK	N071E143	Static-spike-static	in air measurement after changing battery (laptop and em63)	Dieter	Kevin	Alex
E020887AL	N072E142	32		Dieter	Kevin	Alex
E020887AM	N072E142	16	accidentally ended survey after 47, 48 to end in next file set	Dieter	Kevin	Alex
E020887AN	N072E142	16	points 48 to end in next file set	Dieter	Kevin	Alex
E020887AO	N072E141	9		Dieter	Kevin	Alex
E020887AP	N072E141	11		Dieter	Kevin	Alex
E020887AQ	N072E141	3		Dieter	Kevin	Alex
E020887AR	N072E141	13	points 18 and 19 slightly offset due to tree	Dieter	Kevin	Alex
E020887AS	N071E143	Static-spike-static	in air measurement before shutting down for demo shot	Dieter	Kevin	Alex
E020887AT	N071E143	Static-spike-static	in air measurement after restarting following demo shot	Alex	Kevin	Dieter
E020887AU	N072E141	6		Alex	Kevin	Dieter
E020887AV	N072E141	1	coincident with target 14 (originally 2 picks, determined same location in reacquisition)	Alex	Kevin	Dieter
E020887AW	N072E141	10	last target in n072e141	Alex	Kevin	Dieter
E020887AX	N071E141	5	first target in n071e141	Alex	Kevin	Dieter
E020887AY	N071E141	2 (IGNORE)	redo point 48, moving. IGNORE, recollect again next day while testing amplitudes, data looks better from next day	Alex	Kevin	Dieter
E020887AZ	N071E141	7	2 targets just off northern edge of template (703,36), target near corner point 3	Alex	Kevin	Dieter
E020887BA	N071E141	20	redo point 36 moving during recording	Alex	Kevin	Dieter
E020887BB	N071E143	Static-spike-static	in air measurement before changing battery (laptop and em63)	Alex	Kevin	Dieter
E020887BC	N071E143	IGNORE		Alex	Kevin	Dieter
E020887BD	N071E143	Static-spike-static	in air measurement after changing battery (laptop and em63)	Dieter	Kevin	Alex
E020887BE	N071E141	38	ignore first 2 points, forgot to being end survey after restarting.	Dieter	Kevin	Alex
E020887BF	N071E141	16		Dieter	Kevin	Alex

E020887BG	N071E141	33	looks like almost no target response?	Dieter	Kevin	Alex
E020887BH	N071E143	Static-spike-static	end of day calibration test	Dieter	Kevin	Alex
E020887BI	N071E143	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Dieter	Kevin	Alex
		notes	using the entire CSM system (along with the repaired console from Geonics) today			
			up to first battery change, dieter cart, kevin computer, alex templates, up to demo shot, dieter templates, kevin cart, alex computer, next batter change, dieter template, kevin computer, alex cart, final battery change to end of day, dieter cart, kevin computer, alex templates			
March 28 2008			**16 anomalies**			
E020888AA	N071E143	Static-spike-static	start of day calibration, on sawhorses at same location used for the past week. Spike measurement seems very low (~30mV) even though using same target at same location with identical equipment as day before (when values were ~450mV)	Dieter	Kevin	Alex
E020888AB	N071E143	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward	Dieter	Kevin	Alex
E020888AC	N071E141	2	Re-collected this target again to compare amplitudes from yesterday (when spike measurements were normal, and today when they are low.	Dieter	Kevin	Alex
E020888AD	N071E141	13 (IGNORE)	target response off center, recollected on d08095	Dieter	Kevin	Alex
E020888AE	N071E141	11	last target in n071e141	Dieter	Kevin	Alex
E020888AF	N071E142	13	first target in n071e142	Dieter	Kevin	Alex
E020888AG	N071E142	24	recollect point 28, moving	Dieter	Kevin	Alex
E020888AH	N071E142	6	added in the field as an isolated target location, points 18,19slightly off due to tree.	Dieter	Kevin	Alex
E020888AI	N071E143	Static-spike-static	in air measurement before changing battery (laptop and em63). switching from CSM1 em63 battery to CSM2 em63 battery.	Dieter	Kevin	Alex
E020888AJ	N071E143	Static-spike-static	in air measurement after changing battery (laptop and em63)	Kevin	Alex	Dieter
E020888AK	N071E142	30	accidentally started and ended survey without collecting any points/lines. Make sure an extra point wasn't added. Recollect point 24, moving	Kevin	Alex	Dieter
E020888AL	N071E142	67		Kevin	Alex	Dieter
E020888AM	N071E142	10		Kevin	Alex	Dieter
E020888AN	N071E142	33		Kevin	Alex	Dieter
E020888AO	N071E142	25	target 26 near corner point 4, points 1-19 here, remainder in the next survey event	Kevin	Alex	Dieter
E020888AP	N071E142	25	target 26 near corner point 4, points 20-63 here. stump under tarp uneven surface. target 50 near point 34	Kevin	Alex	Dieter
E020888AQ	N071E142	4	target 70 near point 20	Kevin	Alex	Dieter
E020888AR	N071E142	26	target 25 near point 1	Kevin	Alex	Dieter
E020888AS	N071E142	12	same as target 14 in grid N071E143 (target straddles both grids)	Kevin	Alex	Dieter
E020888AT	N071E142	16	same as target 5 in grid n071e143 (target straddles both grids). target 12 just past point 19. last target in n071e142	Kevin	Alex	Dieter
E020888AU	N071E143	51	target 2 near corner 3. First target in N071E143	Kevin	Alex	Dieter
E020888AV	N071E143	Static-spike-static	end of day calibration test, spike still looks low, but same value as other spike measurements for the day?	Kevin	Alex	Dieter
E020888AW	N071E143	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Alex	Dieter
		notes	using the entire CSM system (along with the repaired console from Geonics) today			
			up to first battery change, dieter cart, kevin computer, alex templates. After battery change, dieter templates, kevin cart, alex computer,			

March 29 2008			**25 anomalies**			
E020889AA	N071E143	IGNORE	coils were not connected	Alex	Kevin	Dieter
E020889AB	N071E143	Static-spike-static	start of day calibration, on sawhorses at same location used for the past week. Spike measurement seems low compared to earlier values recorded	Alex	Kevin	Dieter
E020889AC	N071E143	Static-spike-static	using a more substantial item (75mm from McClellan site),values of ~400mV	Alex	Kevin	Dieter
E020889AD	N071E143	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward	Alex	Kevin	Dieter
E020889AE	N071E143	12	target no7143_5 near point 5, recollect point 14, this target was added in field as a surveyable location	Alex	Kevin	Dieter
E020889AF	N071E143	20		Alex	Kevin	Dieter
E020889AG	N071E143	7		Alex	Kevin	Dieter
E020889AH	N071E143	87	point 34 slightly off (30cm east) due to tree	Alex	Kevin	Dieter
E020889AI	N071E143	16	this target was added in field as a surveyable location, target 65 near point 33 and corner point 1. hole near NW edge of template, uneven surface	Alex	Kevin	Dieter
E020889AJ	N071E143	27	this target was added in field as a surveyable location	Alex	Kevin	Dieter
E020889AK	N071E143	41	this target was added in field as a surveyable location, switch laptop batteries after this target	Alex	Kevin	Dieter
E020889AL	N071E143	72	stump under template, uneven surface. point 20 slightly off (15cm south) due to tree	Alex	Kevin	Dieter
E020889AM	N071E143	50	this target was added in field as a surveyable location	Alex	Kevin	Dieter
E020889AN	N071E143	Static-spike-spike-static	changing from csm #2, to csm#1 em63 battery, static-spike-static before changing with both sphere and UXO	Alex	Kevin	Dieter
E020889AO	N071E143	Static-spike-spike-static	after changing battery	Dieter	Kevin	Alex
E020889AP	N071E143	3	this target was added in field as a surveyable location	Dieter	Kevin	Alex
E020889AQ	N071E143	81	recollect point 9, moving	Dieter	Kevin	Alex
E020889AR	N071E143	28	this target was added in field as a surveyable location, target 3 near point 34	Dieter	Kevin	Alex
E020889AS	N071E143	22		Dieter	Kevin	Alex
E020889AT	N071E143	44	this target was added in field as a surveyable location, uneven surface, changed laptop battery after this target	Dieter	Kevin	Alex
E020889AU	N071E143	IGNORE	das did not record a SEN file?, recollected target 35 in next file set	Dieter	Kevin	Alex
E020889AV	N071E143	35	this target was added in field as a surveyable location. last target in n071e143. target 9 near western edge of template	Dieter	Kevin	Alex
E020889AW	N071E143	Static-spike-spike-static	changing from csm#1 em63 battery to erdc battery, static-spike-static before changing with both sphere and UXO	Dieter	Kevin	Alex
E020889AX	N071E143	Static-spike-spike-static	after changing battery	Kevin	Dieter	Alex
E020889AY	N072E143	30	Re-enter N072E143 for additional targets determined to be surveyable in the field	Kevin	Dieter	Alex
E020889AZ	N072E143	4	das stopped collection at point 52, 52 to end in next file set. pulling point 20 to 33 to avoid tree near edge of template. point 20 ~25 centimeters west of marked point. this target was added in field as a surveyable location	Kevin	Dieter	Alex
E020889BA	N072E143	4	points 52-end. recollected point 53	Kevin	Dieter	Alex
E020889BB	N072E143	19	this target was added in field as a surveyable location	Kevin	Dieter	Alex
E020889BC	N072E143	17	this target was added in field as a surveyable location, target 19 near western edge of template	Kevin	Dieter	Alex
E020889BD	N072E143	IGNORE		Kevin	Dieter	Alex
E020889BE	N072E143	23	this target was added in field as a surveyable location., target 40 near southeast corner of template	Kevin	Dieter	Alex
E020889BF	N071E143	Static-spike-spike-static	changing from erdc em63 battery to csm#2, static-spike-static before changing with both sphere and UXO	Kevin	Dieter	Alex
E020889BG	N071E143	Static-spike-spike-static	after changing battery	Kevin	Dieter	Alex

E020889BH	N072E144	20	Re-enter N072E144 for additional targets determined to be surveyable in the field. southwest corner of template near target 12. hole , uneven surface. this target was added in field as a surveyable location	Kevin	Dieter	Alex
E020889BI	N072E144	15	target 9(coincident also with picked target 21) near western edge of template. this target was added in field as a surveyable location	Kevin	Dieter	Alex
E020889BJ	N072E144	1	target 20 near southwest corner of template. this target was added in field as a surveyable location. RECOLLECT point 49 moving during measurement	Kevin	Dieter	Alex
E020889BK	N071E144	48	first target in N071E144, target 5 off eastern edge of template	Kevin	Dieter	Alex
E020889BL	N071E144	6		Kevin	Dieter	Alex
E020889BM	N071E143	Static-spike-spike-static	end of day test with both sphere and McClellan item	Kevin	Dieter	Alex
E020889BN	N071E143	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Dieter	Alex
		notes	using the entire CSM system today			
			up to first battery change, alex cart, kevin computer, dieter templates. After battery change, alex templates, dieter cart, kevin computer, third battery change to end of day, kevin cart, dieter computer, alex templates			
March 31 2008			**23 anomalies**			
E020891AA	N071E143	Static-spike-spike-static	coils were not connected	Dieter	Kevin	Russ
E020891AB	N071E143	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward	Dieter	Kevin	Russ
E020891AC	N071E144	11	target 42 near SW corner of template. target 16 near NE corner of template	Dieter	Kevin	Russ
E020891AD	N071E144	12		Dieter	Kevin	Russ
E020891AE	N071E144	42	this target was added in field as a surveyable location. Almost no detectable response, we'll start excluding low amplitude targets.	Dieter	Kevin	Russ
E020891AF	N071E144	17	this target was added in field as a surveyable location. target 56 (also 108) 30cm off southern edge of template. Uneven surface	Dieter	Kevin	Russ
E020891AG	N071E144	29	stumps, hole, uneven surface	Dieter	Kevin	Russ
E020891AH	N071E144	23	this target was added in field as a surveyable location. target 41 near se corner of template	Dieter	Kevin	Russ
E020891AI	N071E144	8	recollect point 24, moving. changed laptop battery before next target	Dieter	Kevin	Russ
E020891AJ	N071E144	21	recollect point 7, moving	Dieter	Kevin	Russ
E020891AK	N071E144	7		Dieter	Kevin	Russ
E020891AL	N071E144	3	recollect point 5, moving	Dieter	Kevin	Russ
E020891AM	N071E144	15		Dieter	Kevin	Russ
E020891AN	N071E145	3	that was the first target in n071e145	Dieter	Kevin	Russ
E020891AO	N071E143	Static-spike-spike-static	changing from csm #2, to csm#1 em63 battery, static-spike-static before changing with both sphere and uxo	Dieter	Kevin	Russ
E020891APa	N071E143	Static-spike-spike-static	after changing battery. Forgot to end file, target 1 was also in this file set. Break up so that the in air measurement is APa and target 1 is AP	Kevin	Russ	Dieter
E020891AP	N071E145	1	forgot to end survey, remove first 3 points from the next target from the end of this file, restarted for target 2 in the next file set at point 1	Kevin	Russ	Dieter
E020891AQ	N071E145	5 (IGNORE)	looks like recollected same target as 2 locations later and the data is better the 2nd time...)	Kevin	Russ	Dieter
E020891AR	N071E145	2	recollect point 39; moving. Moved tarp 1 ft. east to center target response	Kevin	Russ	Dieter
E020891AS	N071E145	5	juniper battery dying	Kevin	Russ	Dieter
E020891AT	N071E143	Static-spike-spike-static	changing from csm#1 em63 battery to erdc battery, static-spike-static before changing the battery with both sphere and UXO	Kevin	Russ	Dieter

E020891AU	N071E143	Static-spike-spike-static	after changing battery	Kevin	Russ	Dieter
E020891AV	N071E145	4		Kevin	Russ	Dieter
E020891AW	N071E146	7	moved template 1 ft. west to center target response, stump, uneven surface	Kevin	Russ	Dieter
E020891AX	N071E146	2	tarp moved 1 ft. west to center. recollect point 4	Kevin	Russ	Dieter
E020891AY	N071E146	1		Kevin	Russ	Dieter
E020891AZ	N071E146	8	same as n71e4147 #2, target #6 at NW corner of template location. template moved SW to center over target response. this target was added in field as a surveyable location.	Kevin	Russ	Dieter
E020891BA	N071E143	Static-spike-spike-static	before changing em63 battery from csm1 to erdc	Kevin	Russ	Dieter
E020891BB	N071E143	Static-spike-spike-static	after changing battery, laptop and em63	Russ	Kevin	Dieter
E020891BC	N071E146	5	same as n71e147 #3, RECOLLECT 23. pulled points 34-47, tree in way. point 34 slightly off location due to tree (10cm) towards pt 35	Russ	Kevin	Dieter
E020891BD	N071E146	6	this will be the last target in n171e146. target 8 near SE corner of template location. this next one is the first target in n071e147	Russ	Kevin	Dieter
E020891BE	N071E147	9		Russ	Kevin	Dieter
E020891BF	N071E143	Static-spike-spike-static	end of day test with both sphere and McClellan item	Russ	Kevin	Dieter
E020891BG	N071E143	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Russ	Kevin	Dieter
		notes	using the entire CSM system today			
			up to first battery change, dieter cart, kevin computer, russ templates. After battery change, dieter templates, kevin cart, russ computer, third battery change to end of day, russ cart, kevin computer, dieter templates			
April 1 2008			**16 anomalies**			
E028992AA	N072E149	Static-spike-spike-static		Dieter	Kevin	Russ
E028992AB	N072E149	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward	Dieter	Kevin	Russ
E028992AC	N071E147	8	moved template NW ~20cm TO CENTER RESPONSE, UNEVEN SURFACE, HUMP	Dieter	Kevin	Russ
E028992AD	N071E149	Static-spike-spike-static	juniper battery dying, had to change...need a new battery	Dieter	Kevin	Russ
E028992AE	N071E148	17	uneven surface, berm through center for location, juniper battery dying, had to change...need a new battery	Dieter	Kevin	Russ
E028992AF	N071E148	10	shifted template 10cm to SE to center, recollect point 15, uneven surface	Dieter	Kevin	Russ
E028992AG	N071E148	21	last target in this grid, move template 15cm to SW, changed laptop battery after this target	Kevin	Russ	Dieter
E028992AH	N071E149	8		Kevin	Russ	Dieter
E028992AI	N071E149	13	move template 1 ft north to center target response, recollect point 39	Kevin	Russ	Dieter
E028992AJ	N071E150	1	move template 20cm south to center target response	Kevin	Russ	Dieter
E028992AK	N071E150	7	moving template so the center is now at point 54	Kevin	Russ	Dieter
E028992AL	N071E150	4	moving template so the center is now at point 26, recollect point 50	Kevin	Russ	Dieter
E028992AM	N071E149	Static-spike-spike-static	changing from csm #2, to csm#1 em63 battery, static-spike-static before changing with both sphere and UXO	Kevin	Russ	Dieter
E028992AN	N071E149	Static-spike-spike-static	after changing battery	Russ	Kevin	Dieter
E028992AO	N071E150	3	shifted template 10cm to north	Russ	Kevin	Dieter

E028992AP	N071E150	9	shifted template 10cm to south, recollect point 28, point 33 slightly off template location due to tree, switched laptop battery after this target	Russ	Kevin	Dieter
E028992AQ	N071E152	8		Russ	Kevin	Dieter
E028992AR	N071E152	5		Russ	Kevin	Dieter
E028992AS	N071E149	Static-spike-spike-static	ran out of targets on east side of Iron Mtn. rd. need to go to of road. Demo shot exclusion zone delays for almost an hour	Russ	Kevin	Dieter
E028992AT	N073E144	Static-spike-spike-static	calibration location has now been moved to grid N073E144	Kevin	Russ	Dieter
E028992AU	N073E144	2	recollect point 41	Kevin	Russ	Dieter
E028992AV	N073E144	13	uneven surface; hole near center, template moved SW approx.30cm, recollect point 16	Kevin	Russ	Dieter
E028992AW	N073E144	17	same location as target 25 (from the same grid, flags coincident), moved template 1 ft. west to center	Kevin	Russ	Dieter
E028992AX	N073E144	Static-spike-spike-static	end of day test with both sphere and McClellan item	Kevin	Russ	Dieter
E028992AY	N073E144	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Russ	Dieter
		notes	using the entire CSM system today			
			first 3 targets, dieter cart, kevin computer, russ templates. Fourth target until first battery change, dieter templates, kevin cart, russ computer, first battery change to moving across road, russ cart, kevin computer, dieter templates; last 3 targets kevin cart, russ computer, dieter templates			
April 2 2008			**25 anomalies**			
E028993AA	N073E144	Static-spike-spike-static	start of day test with both sphere and McClellan item	Dieter	Kevin	Russ
E028993ABa	N073E144	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward, forgot to end file. Next target and tilt test were both in AB file set. Put tilt in ABa	Dieter	Kevin	Russ
E028993AB	N073E144	14	target 19 near SW corner of template (i.e. near point 1). moved template 10cm north	Dieter	Kevin	Russ
E028993AC	N073E144	3	target 36 near NW corner of template (i.e. point 3). move template 10cm west	Dieter	Kevin	Russ
E028993AD	N073E144	19	target 14 near NE corner of template (point 4). shifted template 15cm SE	Dieter	Kevin	Russ
E028993AE	N073E144	10	also coincident flag for target 38 for a single response in reac. das stopped collecting em63 (even though still green button), no data going to sen file. points 20-end in next file set. Merged all data into the AE file set post survey	Dieter	Kevin	Russ
E028993AF	N073E144	10 (IGNORE)	das stopped again at point 59. 60-end in file set AH	Dieter	Kevin	Russ
E028993AG	N073E144	10 (IGNORE)	no sen file created	Dieter	Kevin	Russ
E028993AH	N073E144	10 (IGNORE)	recollect point 60. IGNORE, no sen file created by software DAS. restarted sDas to try and fix problems with em63 data randomly stopping recording to sen file.	Dieter	Kevin	Russ
E028993AI	N073E144	32	move template 30cm west, recollect point 5	Dieter	Kevin	Russ
E028993AJ	N073E144	1	uneven surface, hole in center. moved template 40cm SW. changed laptop battery after this target	Dieter	Kevin	Russ
E028993AK	N073E144	28		Dieter	Kevin	Russ
E028993AL	N073E144	21	moved template 40cm NW, recollect points 59 and 60	Dieter	Kevin	Russ
E028993AM	N073E144	20	target 29 just off eastern edge of template. move template 40cm SW	Dieter	Kevin	Russ
E028993AN	N073E144	22	shift template 30cm NE, recollect point 19	Dieter	Kevin	Russ
E028993AO	N073E144	8	same as n073e143_46, moved template 20cm NW, target 46A near west edge of template. that was last target in n073e144	Dieter	Kevin	Russ
E028993AP	N073E144	Static-spike-spike-static	before changing from csm2 to csm1 battery	Dieter	Kevin	Russ

E028993AQ	N073E144	Static-spike-spike-static	after changing battery	Kevin	Dieter	Russ
E028993AR	N073E143	9	shifted template 25cm west. first target in N073 E143	Kevin	Dieter	Russ
E028993AS	N073E143	23	uneven surface (stump), shifted template 25cm north	Kevin	Dieter	Russ
E028993AT	N073E143	32		Kevin	Dieter	Russ
E028993AU	N073E143	31	target 4 & 34 near northern edge of template, moved template north 20cm	Kevin	Dieter	Russ
E028993AV	N073E143	19	shifted 50cm west	Kevin	Dieter	Russ
E028993AW	N073E143	3	uneven surface (rocks), moved template 15cm southwest, changed laptop battery	Kevin	Dieter	Russ
E028993AX	N073E143	2	also target 47 in same grid, uneven surface	Kevin	Dieter	Russ
E028993AY	N073E143	6	moved template 20cm north	Kevin	Dieter	Russ
E028993AZ	N072E143	18	entered new grid for recollection of previously poorly centered target. Extremely uneven surface(roots, large hole). moved template west 45cm	Kevin	Dieter	Russ
E028993BA	N073E144	Static-spike-spike-static	before changing from csm1 to erdc battery	Kevin	Dieter	Russ
E028993BB	N073E144	IGNORE	forgot to zero instrument after changing battery	Russ	Kevin	Dieter
E028993BC	N073E144	Static-spike-spike-static	after changing battery	Russ	Kevin	Dieter
E028993BD	N073E143	36		Russ	Kevin	Dieter
E028993BE	N073E143	44	move template 10cm east, target 18(west), 3(north) near edge of template	Russ	Kevin	Dieter
E028993BF	N073E143	21		Russ	Kevin	Dieter
E028993BG	N073E143	29	target 25 near NW corner (point 3)	Russ	Kevin	Dieter
E028993BH	N073E142	1		Russ	Kevin	Dieter
E028993BI	N073E144	Static-spike-spike-static	end of day test with both sphere and McClellan item	Russ	Kevin	Dieter
E028993BJ	N073E144	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Russ	Kevin	Dieter
		notes	using the entire CSM system today			
			Up to first battery, dieter cart, kevin computer, russ templates. Up to second battery change, dieter computer, kevin cart, russ templates, third battery change to end, russ cart, kevin computer, dieter templates			
April 3 2008			**18 anomalies**			
E028994AA	GPO	Static-spike-spike-static	start of day test with both sphere and McClellan item, calibration on a flat area just off the access road	Russ	Kevin	Dieter
E028994AB	GPO	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward	Russ	Kevin	Dieter
E028994AC	GPO	17	recollect point 1	Russ	Kevin	Dieter
E028994AD	GPO	67	pulled points 32, 33, point 34 off, tree in way	Russ	Kevin	Dieter
E028994AE	GPO	32	points 30-33 slightly off due to tree	Russ	Kevin	Dieter
E028994AF	GPO	51	accidentally pulled usb cable after point 4, plugged back in and data started streaming fine, continued with point 5-end in same file set	Russ	Kevin	Dieter
E028994AG	GPO	33	changed laptop battery	Russ	Kevin	Dieter
E028994AH	GPO	36		Dieter	Kevin	Russ
E028994AI	GPO	47	point 47 slightly off location, tree	Dieter	Kevin	Russ
E028994AJ	GPO	37		Dieter	Kevin	Russ
E028994AK	GPO	15		Dieter	Kevin	Russ
E028994AL	GPO	Static-spike-spike-static	before changing csm2 battery to erdc	Dieter	Kevin	Russ
E028994AM	GPO	IGNORE	forgot to zero instrument	Dieter	Kevin	Russ
E028994AN	GPO	Static-spike-spike-static	after changing battery	Dieter	Kevin	Russ
E028994AO	GPO	72	recollect point 34	Dieter	Kevin	Russ
E028994AP	GPO	50		Dieter	Kevin	Russ
E028994AQ	GPO	39	recollect point 19	Dieter	Kevin	Russ

E028994AR	GPO	73	recollect point 17 moving	Dieter	Kevin	Russ
E028994AS	GPO	Static-spike-spike-static	before changing erdc battery to csm1	Dieter	Kevin	Russ
E028994AT	GPO	Static-spike-spike-static	after changing battery	Kevin	Dieter	Russ
E028994AU	GPO	44	point 34 and 35 are off (tree)	Kevin	Dieter	Russ
E028994AV	GPO	14	recollect point 16, points 20,21,22 are off due to tree	Kevin	Dieter	Russ
E028994AW	GPO	21		Kevin	Dieter	Russ
E028994AX	GPO	34		Kevin	Dieter	Russ
E028994AY	GPO	8	target 21 is near northeast corner. ended survey early	Kevin	Dieter	Russ
E028994AZ	GPO	8 (IGNORE)	starting new survey from point 12, merged to create complete survey event in file set AY	Kevin	Dieter	Russ
E028994BA	GPO	Static-spike-spike-static	end of day test with both sphere and McClellan item	Kevin	Dieter	Russ
E028994BB	GPO	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Dieter	Russ
		notes	the GPO is literally on the side of a steeply sloping hill. It was ridiculously steep and difficult to locate and center targets, keep template in place and not slide down the hill. Wound up hammering plastic stakes through tarp and that held tar pin place, only problem was the the surface was still very slippery and it was difficult for cart and cart pusher to not slide straight downhill.			
			using the entire CSM system today			
			first 5 targets, russ cart, kevin computer, dieter templates. Sixth target until second battery change, russ templates, dieter cart, kevin computer, Second battery change to end, russ templates, dieter computer, kevin cart templates; last 3 targets kevin cart			
April 4 2008			**23 anomalies**			
E028995AA	N074E143	Static-spike-spike-static / tilt test	start of day test with both sphere and McClellan item, calibration on a flat area just off the access road. start of day tilt test, right wheel up, left wheel up, pitch forward. Forgot to start new survey event, both calibration in the AB file set	Kevin	Dieter	Russ
E028995AB	N073E142	10	shifted template 30cm west	Kevin	Dieter	Russ
E028995AC	N073E142	2	shifted template 10cm southwest	Kevin	Dieter	Russ
E028995AD	N073E142	IGNORE	ignore this file set recollecting target 15 in file set AE. log not recording, restart DAS	Kevin	Dieter	Russ
E028995AE	N073E142	15	shifted template 10cm west	Kevin	Dieter	Russ
E028995AF	N073E142	IGNORE	ignore file set, accidentally ended survey early	Kevin	Dieter	Russ
E028995AG	N073E142	IGNORE	ignore file set	Kevin	Dieter	Russ
E028995AH	N073E142	3	shifted template 20cm southwest, roots uneven surface	Kevin	Dieter	Russ
E028995AI	N073E142	5	target 12 is near southwest corner	Kevin	Dieter	Russ
E028995AJ	N073E142	11		Kevin	Dieter	Russ
E028995AK	N073E142	12	target 5 near northeast corner, moving template 30cm east, changed laptop battery	Kevin	Dieter	Russ
E028995AL	N073E142	6	moved template 50cm east	Kevin	Dieter	Russ
E028995AM	N073E142	7	recollecting point 9	Kevin	Dieter	Russ
E028995AN	N071E141	13	recollecting target 13 in N071 E 141, shifted template 0.6 meters to southeast	Kevin	Dieter	Russ
E028995AO	N073E141	2	targets 8 and 12 near southwest corner, moved template northwest 25cm	Kevin	Dieter	Russ
E028995AP	N073E141	1	moved template 10cm to northwest, target 5 and 10 near western edge, restarted DAS	Kevin	Dieter	Russ
E028995AQ	N073E141	11	trying collecting over a target where amp. less than 10	Kevin	Dieter	Russ
E028995AR	N074E141	6	moving template 25cm northwest	Kevin	Dieter	Russ
E028995AS	N074E141	5		Kevin	Dieter	Russ
E028995AT	N074E143	Static-spike-spike-static	before changing csm2 battery to csm1	Kevin	Dieter	Russ
E028995AU	N074E143	Static-spike-spike-static	after changing battery	Dieter	Kevin	Russ

E028995AV	N074E141	8	trying another < 10mV target, point 20 slightly off due to tree	Dieter	Kevin	Russ
E028995AW	N074E142	15		Dieter	Kevin	Russ
E028995AX	N074E142	1	same location as target 8, single response (flags coincident). moved template 30cm west	Dieter	Kevin	Russ
E028995AY	N074E142	9		Dieter	Kevin	Russ
E028995AZ	N074E142	12	moved template 10cm NW, points 5,6 slightly off due to tree	Dieter	Kevin	Russ
E028995BA	N074E142	22	move template se 20cm	Dieter	Kevin	Russ
E028995BB	N074E142	4	moved template SW15cm	Kevin	Dieter	Russ
E028995BC	N074E143	12	moved template 30cm west, tornado warning left early	Kevin	Dieter	Russ
E028995BD		Static-spike-spike-static	end of day test with both sphere and McClellan item	Kevin	Dieter	Russ
E028995BE		tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Dieter	Russ
		notes	using the entire CSM system today			
			first 15 targets, kevin cart, dieter computer, russ templates. Next 6 targets, russ templates, dieter cart, kevin computer, last 2 targets: russ templates, dieter computer, kevin cart			
April 5 2008			**26 anomalies**			
E028996AA	N074E143	Static-spike-spike-static	start of day test with both sphere and McClellan item.	Kevin	Dieter	Russ
E028996AB	N074E143	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward.	Kevin	Dieter	Russ
E028996AC	N074E143	6		Kevin	Dieter	Russ
E028996AD	N074E143	9	shifting template 20cm west, target 20 near northern edge of template	Kevin	Dieter	Russ
E028996AE	N074E143	7	shifting template 40cm northwest	Kevin	Dieter	Russ
E028996AF	N074E143	23		Kevin	Dieter	Russ
E028996AG	N074E143	17	shifted template 20cm southeast	Kevin	Dieter	Russ
E028996AH	N074E143	11	shifted template 20cm southwest	Kevin	Dieter	Russ
E028996AI	N074E143	26	shifted template 10cm northwest, uneven surface tree stump	Kevin	Dieter	Russ
E028996AJ	N074E143	21	shifted template 20cm southwest, same target as 40 in grid n074e144, last target in grid 074e143, uneven surface hole in center	Kevin	Dieter	Russ
E028996AK	N074E144	44	new grid n074e144, shifted template 15cm west, uneven surface tree root stump	Kevin	Dieter	Russ
E028996AL	N074E144	4	shifted template 50cm east, uneven surface	Kevin	Dieter	Russ
E028996AM	N074E144	45	shifted template 10cm north, changed laptop battery	Kevin	Dieter	Russ
E028996AN	N074E144	9	move template 30cm SW, target 30 near western edge of template, point 50 slightly off due to tree	Dieter	Kevin	Russ
E028996AO	N074E144	30	target 9 near NE corner of template	Dieter	Kevin	Russ
E028996AP	N074E144	19	shifted template 20cm se, changing from csm2 to csm1 battery	Dieter	Kevin	Russ
E028996AQ	N074E143	Static-spike-spike-static	before changing csm2 battery to csm1	Dieter	Kevin	Russ
E028996AR	N072E148	Static-spike-spike-static	after changing battery, note changed calibration location	Dieter	Kevin	Russ
E028996AS	N074E144	6 (IGNORE)	target 5 near NW corner of template, move template10cm SW	Dieter	Kevin	Russ
E028996AT	N074E144	6	target 5 near NW corner of template, move template10cm SW, recollect target 6, template not centered properly first time	Dieter	Kevin	Russ
E028996AU	N074E144	7	uneven surface	Dieter	Kevin	Russ
E028996AV	N074E144	5	shifted template 10cm NW, target 70 on one corner of template, change laptop battery	Dieter	Kevin	Russ
E028996AW	N072E146	14	shifted template30cm west, uneven surface, Rocks	Dieter	Kevin	Russ
E028996AX	N072E146	1		Dieter	Kevin	Russ
E028996AY	N072E146	4	shifted template 10cm se, point 19 off location due to tree (closer to point 18 location), uneven surface, rocks. template slipping, locations suspect	Dieter	Kevin	Russ

E028996AZ	N072E146	7	target 2 near south edge of template. Russ starts on cart at this target	Russ	Kevin	Dieter
E028996BA	N072E146	2	target 7 near northern edge of template, target 8 near se corner of template	Russ	Kevin	Dieter
E028996BB	N072E146	8	target 2 near NW corner of template, shifted template 10cm west	Russ	Kevin	Dieter
E028996BC	N072E146	11	shifted template 10cm west, target 6 near NE corner of template	Russ	Kevin	Dieter
E028996BD	N074E148	Static-spike-spike-static	before changing csm1 battery to erdc	Russ	Kevin	Dieter
E028996BE	N072E148	Static-spike-spike-static	after changing battery, note changed calibration location	Kevin	Russ	Dieter
E028996BF	N072E147	10	shifted template 15cm east	Kevin	Russ	Dieter
E028996BG	N072E147	7 (IGNORE)	shifted template 15cm southwest, data was also collected on d08098, use the data from that date since it looks marginally better	Kevin	Russ	Dieter
E028996BH	N072E148	Static-spike-spike-static	end of day test with both sphere and McClellan item	Kevin	Russ	Dieter
E028996BI	N072E148	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Russ	Dieter
		notes	using the entire CSM system today			
			first 11 targets, kevin cart, dieter computer, russ templates. Next 9 targets, russ templates, dieter cart, kevin computer, next 4 targets: russ cart, kevin, computer, dieter templates; last 2 targets kevin cart, russ computer, dieter templates			
April 7 2008			**26 anomalies**			
E028998AA	N072E148	Static-spike-spike-static	start of day test with both sphere and McClellan item.	Dieter	Kevin	Russ
E028998AB	N072E148	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward.	Dieter	Kevin	Russ
E028998AC	N072E147	8	standing water present	Dieter	Kevin	Russ
E028998AD	N072E147	7		Dieter	Kevin	Russ
E028998AE	N072E147	17		Dieter	Kevin	Russ
E028998AF	N072E147	4	uneven surface, slope, recollect point 37	Dieter	Kevin	Russ
E028998AG	N072E147	18		Dieter	Kevin	Russ
E028998AH	N072E148	3	target 14 near SW corner of template	Dieter	Kevin	Russ
E028998AI	N072E148	1	shifted template to NE 25cm	Dieter	Kevin	Russ
E028998AJ	N072E148	2	shifted template 15cm NW	Dieter	Kevin	Russ
E028998AK	N072E148	8	target 15 near northern edge of template, target 12 near E edge of template, shifted template 10cm NW. changed laptop battery	Dieter	Kevin	Russ
E028998AL	N072E149	1	target 11 near NW corner of template, points 20, 21 off due to tree	Dieter	Kevin	Russ
E028998AM	N072E150	3	shifted template 50cm west	Dieter	Kevin	Russ
E028998AN	N072E150	5	shifted template 30cm NW	Dieter	Kevin	Russ
E028998AO	N072E148	Static-spike-spike-static	before changing csm2 battery to erdc	Dieter	Kevin	Russ
E028998AP	N072E148	Static-spike(ignore)-spike spike-static	after changing battery, ignore first spike, someone walked up to sensor	Dieter	Kevin	Russ
E028998AQ	N072E151	2	shifted template 20cm W	Dieter	Kevin	Russ
E028998AR	N072E151	8	shift template 10cm SW	Dieter	Kevin	Russ
E028998AS	N072E151	6	switched laptop battery	Dieter	Kevin	Russ
E028998AT	N072E151	4	shifted template 10c west	Dieter	Kevin	Russ
E028998AU	N072E148	Static-spike-spike-static	moving to new set of grids, switching from erdc to csm 1	Dieter	Kevin	Russ
E028998AV	N077E144	Static-spike-spike-static	note new calibration location	Kevin	Dieter	Russ

E028998AW	N077E145	7	point 34 & 35 are off due to tree, recollecting point 54	Kevin	Dieter	Russ
E028998AX	N077E145	5	move template 50cm northeast, restarted DAS	Kevin	Dieter	Russ
E028998AY	N077E145	23	moved template 20cm east	Kevin	Dieter	Russ
E028998AZ	N077E145	3	target 31 at northern edge of template, uneven surface hole, shifted template 20cm south	Kevin	Dieter	Russ
E028998BA	N077E144	8	moved template 25cm northeast	Kevin	Dieter	Russ
E028998BB	N077E144	31	moved target 20cm south, changed laptop battery	Kevin	Dieter	Russ
E028998BC	N077E144	16	also same as target 23 in the n077e143 grid, uneven surface rocks, target 807 near southern edge of template, steel survey pin near southeast edge of template	Kevin	Dieter	Russ
E028998BD	N077E144	6	moved template west 20cm, target 25a near southeast corner, point 19 is slightly off due to tree	Kevin	Dieter	Russ
E028998BE	N077E144	4		Kevin	Dieter	Russ
E028998BF	N077E144	17	moved template 25cm southeast, recollect point 13	Kevin	Dieter	Russ
E028998BG	N077E144	Static-spike-spike-static	end of day test with both sphere and McClellan item	Kevin	Dieter	Russ
E028998BH	N077E144	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Dieter	Russ
		notes	using the entire CSM system today			
			first 16 targets, dieter cart, kevin computer, russ templates. Next 10 targets, russ templates, kevin cart, dieter computer			
			background values seemed elevated in the early grids, seemed more normal when switched to the N077 series of grids in the afternoon.			
April 8 2008			**28 anomalies**			
E028999AA	N077E144	Static-spike-spike-static	start of day test with both sphere and McClellan item.	Kevin	Dieter	Russ
E028999AB	N077E144	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward.	Kevin	Dieter	Russ
E028999AC	N077E143	1	uneven surface, moved template 25cm south, target 49 on eastern edge of template	Kevin	Dieter	Russ
E028999AD	N077E143	2	shifted template 10cm west	Kevin	Dieter	Russ
E028999AE	N077E143	24	uneven surface, shifted template 10cm southwest	Kevin	Dieter	Russ
E028999AF	N077E143	75		Kevin	Dieter	Russ
E028999AG	N078E143	22		Kevin	Dieter	Russ
E028999AH	N078E143	25	point 34 & 35 are off (tree)	Kevin	Dieter	Russ
E028999AI	N078E143	15	shifted template north 10cm	Kevin	Dieter	Russ
E028999AJ	N078E143	31	uneven surface - branches	Kevin	Dieter	Russ
E028999AK	N078E143	7		Kevin	Dieter	Russ
E028999AL	N078E143	10	same location as target 14	Kevin	Dieter	Russ
E028999AM	N078E144	8		Kevin	Dieter	Russ
E028999AN	N078E144	3 (IGNORE)	recollected, not centered properly	Kevin	Dieter	Russ
E028999AO	N078E144	3	shifted template 40cm southeast	Kevin	Dieter	Russ
E028999AP	N078E144	1	shifted template 10cm west	Kevin	Dieter	Russ
E028999AQ	N078E144	6	uneven surface roots, shifted 20cm southwest	Kevin	Dieter	Russ
E028999AR	N077E144	Static-spike-spike-static	before switching from csm2 to csm1 em63 battery	Kevin	Dieter	Russ
E028999AS	N077E144	Static-spike-spike-static	after changing battery	Dieter	Kevin	Russ
E028999AT	N078E144	2	stump, uneven surface, shift template 10cm south	Dieter	Kevin	Russ
E028999AU	N078E144	4	move template 25cm SW	Dieter	Kevin	Russ
E028999AV	N078E145	19	shift template 10cm NE	Dieter	Kevin	Russ
E028999AW	N078E145	11	shift template w 15cm	Dieter	Kevin	Russ
E028999AX	N078E145	1		Dieter	Kevin	Russ
E028999AY	N078E145	3	same location as target 28, shift template SW 20cm, target 17 near west edge of template, target 26 also near west edge of template	Dieter	Kevin	Russ
E028999AZ	N078E145	9	same as target 29 from adjacent grid n079e145	Dieter	Kevin	Russ
E028999BA	N078E145	20		Dieter	Kevin	Russ
E028999BB	N078E145	22	rocks, stump uneven surface	Dieter	Kevin	Russ

E028999BC	N079E144	2	shift template 15cm NE	Dieter	Kevin	Russ
E028999BD	N077E144	Static-spike-spike-static	before switching from csm1 to erdc EM63 battery	Dieter	Kevin	Russ
E028999BE	N077E144	Static-spike-spike-static	after changing battery	Russ	Kevin	Dieter
E028999BF	N079E144	10		Russ	Kevin	Dieter
E028999BG	N079E144	29		Russ	Kevin	Dieter
E028999BH	N079E144	1	same as target 52 and 54 from same grid, uneven surface hole in center	Russ	Kevin	Dieter
E028999BI	N079E144	6	same location as target 8, shift template 10cm SE	Russ	Kevin	Dieter
E028999BJ	N077E144	Static-spike-spike-static	end of day test with both sphere and McClellan item	Russ	Kevin	Dieter
E028999BK	N077E144	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Russ	Kevin	Dieter
		notes	using the entire CSM system today			
			first 14 targets, dieter computer, kevin cart, russ templates. Next 10 targets, russ templates, kevin computer, dieter cart, final 4 targets russ cart, dieter templates, kevin computer			
April 9 2008			**29 anomalies**			
E0208100AA	N077E144	Static-spike-spike-static	start of day test with both sphere and McClellan item.	Kevin	Dieter	Russ
E0208100AB	N077E144	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward.	Kevin	Dieter	Russ
E0208100AC	N079E144	7	shifted template 10cm west, points 32 and 33 are slightly off (tree)	Kevin	Dieter	Russ
E0208100AD	N079E144	4	shifted template 30cm north. ended survey early by accident. This contains points 1-59	Kevin	Dieter	Russ
E0208100AE	N079E144	4 (IGNORE)	points 60-63, merged into the AD file set for a complete template	Kevin	Dieter	Russ
E0208100AF	N079E144	13	shifted template 50cm southwest	Kevin	Dieter	Russ
E0208100AG	N079E144	21	shifted template 20cm south	Kevin	Dieter	Russ
E0208100AH	N079E144	30	shifted template 20cm southwest	Kevin	Dieter	Russ
E0208100AI	N079E143	21	shifted template 20cm north, recollect point 36	Kevin	Dieter	Russ
E0208100AJ	N079E143	1	shifted template 30cm west	Kevin	Dieter	Russ
E0208100AK	N079E143	18		Kevin	Dieter	Russ
E0208100AL	N079E143	17	shifted template 25cm south, recollect point 5, ended survey early again by accident, points 51-63 in the next file set	Kevin	Dieter	Russ
E0208100AM	N079E143	17 (IGNORE)	points 51-63, merged into the AL file set for a complete template	Kevin	Dieter	Russ
E0208100AN	N079E143	15	shifting template southwest 15cm, target 30 near southern edge of template	Kevin	Dieter	Russ
E0208100AO	N080E143	2	shifting template 20cm northwest	Kevin	Dieter	Russ
E0208100AP	N080E143	21	shifting template 10cm west, target 34 near western edge of template	Kevin	Dieter	Russ
E0208100AQ	N080E143	19		Kevin	Dieter	Russ
E0208100AR	N080E143	8	recollect point 28, point 46 and 47 are off (tree)	Kevin	Dieter	Russ
E0208100AS	N077E144	Static-spike-spike-static	before switching from csm2 to csm1 erdc battery	Kevin	Dieter	Russ
E0208100AT	N077E144	Static-spike-spike-static	after changing battery	Dieter	Kevin	Russ
E0208100AU	N080E143	12	points 5, 6 off due to tree, target 34 near north edge of template,	Dieter	Kevin	Russ
E0208100AV	N080E143	15		Dieter	Kevin	Russ
E0208100AW	N080E143	5	target 10 near NW corner of template, shift template 10cm W	Dieter	Kevin	Russ
E0208100AX	N080E143	20	shift template 10cm E, recollect point 42	Dieter	Kevin	Russ
E0208100AY	N080E143	16	shift template 20cm W	Dieter	Kevin	Russ
E0208100AZ	N080E143	13	point 47 slightly off due to tree	Dieter	Kevin	Russ

E0208100BA	N077E144	Static-spike-spike-static	before switching from erdc to csm1 em63 battery	Dieter	Kevin	Russ
E0208100BB	N077E144	Static-spike-spike-static	after changing battery	Russ	Kevin	Dieter
E0208100BC	N080E143	1	same as target 2 in n081e144, shift template 15cm N	Russ	Kevin	Dieter
E0208100BD	N080E143	4	uneven surface, rocks. target 27 near S edge of template	Russ	Kevin	Dieter
E0208100BE	N080E143	23		Russ	Kevin	Dieter
E0208100BF	N080E144	7	shift template 10cm N	Russ	Kevin	Dieter
E0208100BG	N080E144	5	shift template 10cm NW	Russ	Kevin	Dieter
E0208100BH	N080E144	9	shift template 40cm N, recollect point 10	Russ	Kevin	Dieter
E0208100BI	N080E144	1	same location as target 3, recollect point 18, point 19 slightly off; tree	Kevin	Russ	Dieter
E0208100BJ	N080E144	17		Kevin	Russ	Dieter
E0208100BK	N080E144	19	same location as target 15 in N080E145, shifted template 20cm to NE	Kevin	Russ	Dieter
E0208100BL	N077E144	Static-spike-spike-static	end of day test with both sphere and McClellan item	Kevin	Russ	Dieter
E0208100BM	N077E144	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Russ	Dieter
		notes	using the entire CSM system today			
			first 14 targets, dieter computer, kevin cart, russ templates. Next 6 targets, russ templates, kevin computer, dieter cart, next 6 targets russ cart, dieter templates, kevin computer. last 3 targets, russ computer, kevin cart, dieter templates			
April 10 2008			**24 anomalies**			
E0208101AA	N073E151	Static-spike-spike-static	start of day test with both sphere and McClellan item.	Dieter	Kevin	Russ
E0208101AB	N073E151	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward.	Dieter	Kevin	Russ
E0208101AC	N073E151	11	shift template 10cm E	Dieter	Kevin	Russ
E0208101AD	N073E151	3	shift template 10cm SW	Dieter	Kevin	Russ
E0208101AE	N073E151	9	target 47 near SW corner of template. uneven surface, stump	Dieter	Kevin	Russ
E0208101AF	N073E151	10	shift template 10cm NE, points 46,47 off due to tree	Dieter	Kevin	Russ
E0208101AG	N073E151	2	uneven surface	Dieter	Kevin	Russ
E0208101AH	N073E150	5	shift template 10cm W, target 63 near W edge of template, target 16 near N edge f template	Dieter	Kevin	Russ
E0208101AI	N073E150	1	same as target 2 in N073e149, target 34 (from n073e149) at the SW corner of template, target 9, (same as target 66 from n073e149) near W edge of templates hit template 20cm E. An extra point 63 recorded in file, deleted	Dieter	Kevin	Russ
E0208101AJ	N073E149	18	shifted template 10cm west	Dieter	Kevin	Russ
E0208101AK	N073E149	5	same location as target 45, rocky surface	Dieter	Kevin	Russ
E0208101AL	N073E149	14	shifted template 30cm southwest	Dieter	Kevin	Russ
E0208101AM	N073E149	26	uneven surface hole in center, shifted template 10cm north, target 41 near southwest corner of template	Dieter	Kevin	Russ
E0208101AN	N073E151	Static-spike-spike-static	before switching from csm2 to csm1 battery	Dieter	Kevin	Russ
E0208101AO	N073E151	Static-spike-spike-static	after changing battery	Kevin	Dieter	Russ
E0208101AP	N073E148	6	shifted template 20cm west	Kevin	Dieter	Russ
E0208101AQ	N073E148	13	shifted template 40cm southwest, target 1 near southeast corner	Kevin	Dieter	Russ
E0208101AR	N073E148	4	shifted template 25cm southwest, target 53 near south eastern edge of template, recollect point 34	Kevin	Dieter	Russ
E0208101AS	N073E148	10	uneven surface tree stump, shifted template 30cm east, looks like 2 peaks instead of one	Kevin	Dieter	Russ
E0208101AT	N074E148	27	shifted template 30cm north, target 51 near western edge of template, recollect point 37	Kevin	Dieter	Russ

E0208101AU	N074E148	16 (IGNORE)	points 1-3 only, ended survey early. Merged in next file set for a complete template	Kevin	Dieter	Russ
E0208101AV	N074E148	16	same location as target 58, shifted template 50cm southwest, target on slope	Kevin	Dieter	Russ
E0208101AW	N074E148	28	shifted template 20cm southeast, uneven surface tree stump	Kevin	Dieter	Russ
E0208101AX	N074E149	12	uneven surface (rocks), shifted template 10cm north	Kevin	Dieter	Russ
E0208101AY	N074E149	11	shifted template 25cm west	Kevin	Dieter	Russ
E0208101AZ	N073E151	Static-spike-spike-static	before switching from csm1 to erdc em63 battery	Kevin	Dieter	Russ
E0208101BA	N073E151	IGNORE		Russ	Kevin	Dieter
E0208101BB	N073E151	Static-spike-spike-static	after changing battery	Russ	Kevin	Dieter
E0208101BC	N074E149	8	shift template 10cm N	Russ	Kevin	Dieter
E0208101BD	N074E149	1	target 16 under NE corner of template	Russ	Kevin	Dieter
E0208101BE	N074E149	3	hole in center, uneven surface, shift template 30cm SE	Russ	Kevin	Dieter
E0208101BF	N074E149	10	shift template 10cm W	Russ	Kevin	Dieter
E0208101BG	N073E151	Static-spike-spike-static	end of day test with both sphere and McClellan item	Russ	Kevin	Dieter
E0208101BH	N073E151	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Russ	Kevin	Dieter
		notes	using the entire CSM system today			
			first 11 targets, kevin computer, dieter cart, russ templates. Next 9 targets, russ templates, kevin cart, dieter computer. last 4 targets, russ cart, kevin computer, dieter templates			
April 11 2008			**24 anomalies**			
E0208102AA	N073E151	Static-spike-spike-static	start of day test with both sphere and McClellan item.	Russ	Kevin	Dieter
E0208102AB	N073E151	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward.	Russ	Kevin	Dieter
E0208102AC	N074E149	6	shift template 20cm W, target 2, 9 near N edge of template	Russ	Kevin	Dieter
E0208102AD	N074E150	9		Russ	Kevin	Dieter
E0208102AE	N074E150	10	points 18,19 off (tree)	Russ	Kevin	Dieter
E0208102AF	N073E151	Static-spike-spike-static	moving to new set of grids, switching from erdc to csm2 battery	Russ	Kevin	Dieter
E0208102AG	N077E147	Static-spike-spike-static		Kevin	Russ	Dieter
E0208102AH	N077E147	IGNORE	em63 data view not updating closed and opened ports ignore file set	Kevin	Russ	Dieter
E0208102AI	N077E147	3	target 91 near western edge of template	Kevin	Russ	Dieter
E0208102AJ	N077E147	23	uneven surface (slope), ditch running through target	Kevin	Russ	Dieter
E0208102AK	N077E147	54	uneven surface tree stump	Kevin	Russ	Dieter
E0208102AL	N077E147	67	shifted template 10cm north	Kevin	Russ	Dieter
E0208102AM	N077E147	57	shifting template 15cm northwest, target 91 near northeastern edge of template, point 47 is slightly off (tree), recollect point 56	Kevin	Russ	Dieter
E0208102AN	N077E147	48	shifting template 30cm west	Kevin	Russ	Dieter
E0208102AO	N077E147	31	shifting template 20cm southwest, target 4 (same location as target 94) near southeastern edge of template	Kevin	Russ	Dieter
E0208102AP	N077E147	44	shifting template 30cm northwest	Kevin	Russ	Dieter
E0208102AQ	N077E146	24	shifting template 30cm northeast	Kevin	Russ	Dieter
E0208102AR	N077E146	47		Kevin	Russ	Dieter
E0208102AS	N077E146	41	shifted template 10cm west, uneven surface, rocks	Kevin	Russ	Dieter
E0208102AT	N077E146	25	uneven surface (slope), shifted template 20cm northeast	Kevin	Russ	Dieter
E0208102AU	N077E146	31	shifted template 30cm north	Kevin	Russ	Dieter
E0208102AV	N077E146	31 (IGNORE)	ended survey early, merged these points with those in the previous file set for a complete template, recollect point 39, uneven surface slope	Kevin	Russ	Dieter

E0208102AW	N077E147	Static-spike-spike-static	before switching from csm2 to csm1 battery	Kevin	Russ	Dieter
E0208102AX	N077E147	Static-spike-spike-static	after changing battery	Dieter	Kevin	Russ
E0208102AY	N077E146	1	shift template 10cm SE, target 16 near SW corner of template	Dieter	Kevin	Russ
E0208102AZ	N077E146	16		Dieter	Kevin	Russ
E0208102BA	N078E146	65		Dieter	Kevin	Russ
E0208102BB	N078E146	12	shift template 10cm N	Dieter	Kevin	Russ
E0208102BC	N078E146	62	shift template 15cm NE	Dieter	Kevin	Russ
E0208102BD	N078E146	47	shift template 15cm NE, recollect point 27	Dieter	Kevin	Russ
E0208102BE	N078E147	2	same as target 14 in n078e146, shift template 30cm SE	Dieter	Kevin	Russ
E0208102BF	N078E147	1	uneven surface, target in ditch	Dieter	Kevin	Russ
E0208102BG	N078E147	21 (IGNORE)	shift template 10cm S, bad data, missing points in SEN file	Dieter	Kevin	Russ
E0208102BH	N073E151	Static-spike-spike-static	end of day test with both sphere and McClellan item	Dieter	Kevin	Russ
E0208102BI	N073E151	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Dieter	Kevin	Russ
		notes	using the entire CSM system today			
			first 3 targets, dieter templates, kevin computer, russ cart. Next 12 targets, russ computer, kevin cart, dieter templates. last 9 targets, kevin computer, dieter cart, russ templates			
April 12 2008			**23 anomalies**			
E0208103AA	test pit	Static-spike-spike-static	start of day test with both sphere and McClellan item.	Dieter	Kevin	
E0208103AB	test pit	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward.	Dieter	Kevin	
E0208103AC	test pit	2.36 inch rocket	vertical, d=19cm	Dieter	Kevin	
E0208103AD	test pit	60mm mortar	vertical, d=10cm	Dieter	Kevin	
E0208103AE	test pit	2.36 inch rocket	45 degrees, d=18cm	Kevin	Dieter	
E0208103AF	test pit	60mm mortar	45 degrees, d=6cm	Kevin	Dieter	
E0208103AG	test pit	2.36 inch rocket	horizontal, d=18.5cm	Dieter	Kevin	
E0208103AH	test pit	60mm mortar	horizontal, d=6cm	Dieter	Kevin	
E0208103AI	test pit	deep pit (empty)		Kevin	Dieter	
E0208103AJ	test pit	shallow pit (empty)		Kevin	Dieter	
E0208103AK	test pit	3 inch stokes mortar	vertical, d=16.5cm	Dieter	Kevin	
E0208103AL	test pit	MKII grenade	vertical, d=5.5cm	Dieter	Kevin	
E0208103AM	test pit	3 inch stokes mortar	45 degrees, d=18cm	Kevin	Dieter	
E0208103AN	test pit	MKII grenade	45 degrees, d=5.5cm	Kevin	Dieter	
E0208103AO	test pit	3 inch stokes mortar	horizontal, d=19.5cm	Dieter	Kevin	
E0208103AP	test pit	MKII grenade	horizontal, d=6.5cm	Dieter	Kevin	
E0208103AQ	test pit	Static-spike-spike-static	before switching from csm2 to csm1 battery	Dieter	Kevin	

E0208103AR	test pit	Static-spike-spike-static	after changing battery	Kevin	Dieter	
E0208103AS	test pit	3.8 inch shrapnel round	vertical, d=20cm	Kevin	Dieter	
E0208103AT	test pit	37mm projectile	vertical, d=6cm	Kevin	Dieter	
E0208103AU	test pit	3.8 inch shrapnel round	45 degrees, d=19.5cm	Dieter	Kevin	
E0208103AV	test pit	37mm projectile	45 degrees, d=6cm	Dieter	Kevin	
E0208103AW	test pit	3.8 inch shrapnel round	horizontal, d=19.5cm	Kevin	Dieter	
E0208103AX	test pit	37mm projectile	horizontal, d=6cm	Kevin	Dieter	
E0208103AY	test pit	75mm shrapnel round	vertical, 22cm	Dieter	Kevin	
E0208103AZ	test pit	75mm shrapnel round	45 degrees, 19.5cm	Dieter	Kevin	
E0208103BA	test pit	75mm shrapnel round	horizontal, 19.5cm	Kevin	Dieter	
E0208103BB	test pit	Static-spike-spike-static	end of day test with both sphere and McClellan item	Kevin	Dieter	
E0208103BC	test pit	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Dieter	
		notes	using the entire CSM system today			
			for horizontal and 45 degree targets, the depth was measured from the surface to the top of the target center of mass. For vertical targets, the depth was measured to the center of mass. Photos were taken that illustrate the point on each ordnance where the depth was measured.			
April 14 2008			**21 anomalies**			
E0208105AA	N071E146	Static-spike-spike-static	start of day test with both sphere and McClellan item.	Dieter	Kevin	
E0208105AB	N071E146	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward.	Dieter	Kevin	
E0208105AC	N069E143	98	shift template 30cm NW, target 28 (115) near N edge	Dieter	Kevin	
E0208105AD		41	targets 68(72) near western edge	Dieter	Kevin	
E0208105AE		41 (IGNORE)	ended survey early, merged these points with those in the previous file set for a complete template	Dieter	Kevin	
E0208105AF		21	same location as target 92, shifted template 30cm southwest	Kevin	Dieter	
E0208105AG	N069E144	28	switched grids to stay away from NAEVA reaq team, same location as target 53, uneven surface stump, shift template 30cm SW	Kevin	Dieter	
E0208105AH		13	same location as target 29, shift template 25cm SW	Dieter	Kevin	
E0208105AI		19	pulling points 5 to 19 (tree in way), points 5 & 6 slightly off location (tree), shifted template 25cm SW	Dieter	Kevin	
E0208105AJ		12	shifted template 15cm west, uneven slope hole in center, pulling points 5 to 19 (tree)	Kevin	Dieter	
E0208105AK		3	same location as target 10, shift template 25cm W	Kevin	Dieter	
E0208105AL		32	pulled points 5-19 tree in way, shift template 25cm SW	Kevin	Dieter	
E0208105AM	N069E144	Static-spike-spike static	before switching from csm2 to erdc battery. Note, current on csm2 battery had dropped to below 12 A but data still looked ok	Kevin	Dieter	

E0208105AN	N069E144	Static-spike-spike-static	after changing battery	Dieter	Kevin	
E0208105AO		27	target 4 near western edge, shifted template 10cm east, point 34 is off due to tree	Dieter	Kevin	
E0208105AP		18	shifted template 10cm E, points 18 & 19 are slightly off due to tree	Dieter	Kevin	
E0208105AQ		7	same location as target 34, shift template 25cm W	Kevin	Dieter	
E0208105AR		17	shift template 25cm W	Kevin	Dieter	
E0208105AS		21	same location as target 22 and target 66 from n069e143	Dieter	Kevin	
E0208105AT		39	shifting template NW 15cm	Dieter	Kevin	
E0208105AU	N069E144	Static-spike-spike-static	before switching from erdc to csm1 battery	Dieter	Kevin	
E0208105AV	N069E144	Static-spike-spike-static	after changing battery	Kevin	Dieter	
E0208105AW		30	shift template 10cm NW	Kevin	Dieter	
E0208105AX		24	shift template 10cm S	Kevin	Dieter	
E0208105AY	N069E143	8	shifting template 15cm north	Dieter	Kevin	
E0208105AZ		9	shifting template 10cm south, target 4(80) near SW corner of template	Dieter	Kevin	
E0208105BA		1	uneven surface, hole in center, target 56 near NE corner, shifted template 40cm south	Kevin	Dieter	
E0208105BB		65	shifting template 30cmSW, target 71 near western edge	Kevin	Dieter	
E0208105BC	N069E144	Static-spike-spike-static	end of day test with both sphere and McClellan item	Kevin	Dieter	
E0208105BD	N069E144	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Dieter	
		notes	using the entire CSM system today			
			alternating, 2 targets each then switch templates and switch cat/computer.			
			EM61 reaq team was scheduled to work nearby, but kept them at least 150 feet away at all times			
			with only 2 person crew, did not take any photos of picked location that chose not to survey because of obstructions, only took photos of the surveyed locations.			
April 15 2008			**25 anomalies**			
E0208106AA	N082E144	Static-spike-spike-static	start of day test with both sphere and McClellan item.	Dieter	Kevin	Brian
E0208106AB	N082E144	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward.	Dieter	Kevin	Brian
E0208106AC	N082E144	24	shift template 10cm southwest	Dieter	Kevin	Brian
E0208106AD	N082E144	1	shift template 30cm northeast	Dieter	Kevin	Brian
E0208106AE	N082E144	47	shift template 15cm east	Dieter	Kevin	Brian
E0208106AF	N082E144	22	target 28 at western edge of template, uneven surface-stump	Dieter	Kevin	Brian
E0208106AG	N082E144	3		Dieter	Kevin	Brian
E0208106AH	N082E144	48	shift template 25cm to east	Dieter	Kevin	Brian
E0208106AI	N082E144	16	uneven surface-stump, shift template 40cm to east, recollect point 27	Dieter	Kevin	Brian
E0208106AJ	N082E144	5	shift template 20cm south, target 35 near southeast corner, target 8 near SW corner, target 11 and 36 near NE corner	Dieter	Kevin	Brian
E0208106AK	N082E144	15		Dieter	Kevin	Brian
E0208106AL	N082E144	39		Dieter	Kevin	Brian
E0208106AM	N082E145	25	shift template 20cm to NE points 20,21,22,53 slightly off (tree)	Dieter	Kevin	Brian

E0208106AN	N082E144	Static-spike-spike-static	changing from csm2 to erdc battery	Dieter	Kevin	Brian
E0208106AO	N082E144	Static-spike-spike-static	after changing battery	Brian	Kevin	Dieter
E0208106AP	N082E145	6	same location as target 23, shift template 10cm S	Brian	Kevin	Dieter
E0208106AQ	N082E145	7	same location as target 15, 48 from same grid and target 68 from n082e144, shift template 10cm SW	Brian	Kevin	Dieter
E0208106AR	N082E145	8	same location as target 12, targets 14, 45 near W edge of template, recollect point 53	Brian	Kevin	Dieter
E0208106AS	N082E145	3	same location as target 5, shift template 15cm N, point 34 off (tree)	Brian	Kevin	Dieter
E0208106AT	N082E145	2	same location as target 10, shift template 10cm N	Brian	Kevin	Dieter
E0208106AU	N082E145	29	same location as target 37, shift template 10cm SE	Brian	Kevin	Dieter
E0208106AV	N082E145	4	same location as target 42, shift template 10cm E, point 33 off (tree)	Brian	Kevin	Dieter
E0208106AW	N082E144	Static-spike-spike-static	before switching from erdc to csm1 battery	Brian	Kevin	Dieter
E0208106AX	N082E144	IGNORE	did not zero em63 before starting to record	Kevin	Brian	Dieter
E0208106AY	N082E144	Static-spike-spike-static	after changing battery	Kevin	Brian	Dieter
E0208106AZ	N082E145	27 (IGNORE)	had to shut down for demo shot, just recollect after demo	Kevin	Brian	Dieter
E0208106BA	N082E144	Static-spike-spike-static	after powering system back up after demo shot	Kevin	Brian	Dieter
E0208106BB	N082E145	27	target 20 near SW corner of template	Kevin	Brian	Dieter
E0208106BC	N082E145	36	same location as target 38, shift template 10cm S, point 20 off (tree)	Kevin	Brian	Dieter
E0208106BD	N082E145	28	uneven surface, large rock under template, shift template 10cm SE	Kevin	Brian	Dieter
E0208106BE	N082E145	34	shift template 10cm SW	Kevin	Brian	Dieter
E0208106BF	N081E144	3	shift template 10cm W, target 10 near N edge of template	Kevin	Brian	Dieter
E0208106BG	N081E144	1	uneven surface hole in center	Kevin	Brian	Dieter
E0208106BH	N081E144	18	shift template 10cm SE, target 35 near NW corner of template	Kevin	Brian	Dieter
E0208106BI	N082E144	Static-spike-spike-static	end of day test with both sphere and McClellan item	Kevin	Brian	Dieter
E0208106BJ	N082E144	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Brian	Dieter
		notes	using the entire CSM system today			
			EM61 reaq team was scheduled to working nearby, but kept them at least 150 feet away at all times			
April 16 2008			**25 anomalies**			
E0208107AA	N070E144	Static-spike-spike-static	start of day test with both sphere and McClellan item.	Brian	Kevin	Dieter
E0208107AB	N070E144	tilt test	start of day tilt test, right wheel up, left wheel up, pitch forward.	Brian	Kevin	Dieter
E0208107AC	N069E143	81	same location as target 104, shift template 30cm NE, target 28 (115) near NE corner of template	Brian	Kevin	Dieter
E0208107AD	N069E143	28	same location as target 115, shift template 10cm SW, target 81 (104) near SW corner of template, recollect point 49 and 50	Brian	Kevin	Dieter
E0208107AE	N069E143	90	shift template 20cm SW	Brian	Kevin	Dieter
E0208107AF	N069E143	56 (IGNORE)	not above background values	Brian	Kevin	Dieter
E0208107AG	N069E143	76	shift 10cm SE	Brian	Kevin	Dieter
E0208107AH	N069E143	15	same location as target 47, shift 10cm SE, targets 42, 43 near SE corner of template, uneven, hole	Brian	Kevin	Dieter
E0208107AI	N069E143	2	target 37 near W edge of template, target 11 near S edge of template, shift 10cm S	Brian	Kevin	Dieter

E0208107AJ	N069E143	7	shift 10cm W	Brian	Kevin	Dieter
E0208107AK	N069E143	37	shift 25cm SW, target 11 just off SE corner of template, target 2 off E edge of template	Brian	Kevin	Dieter
E0208107AL	N069E143	3	same location of target 19, target 83 off E edge template, shift 30cm SE, slope uneven surface	Brian	Kevin	Dieter
E0208107AM	N069E143	23	same location as target 84, shift 10cm E	Brian	Kevin	Dieter
E0208107AN	N070E143	8	same location as targets 47, 122	Brian	Kevin	Dieter
E0208107AO	N070E144	Static-spike-spike-static	changing from csm2 to erdc battery	Brian	Kevin	Dieter
E0208107AP	N070E144	Static-spike-spike spike	after changing battery	Dieter	Kevin	Brian
E0208107AQ	N070E144	static	ended survey early, final static	Dieter	Kevin	Brian
E0208107AR	N070E143	29	same location as target 85, 126, shift 10cm N, points 20,21 off (tree)	Dieter	Kevin	Brian
E0208107AS	N070E143	28	uneven surface, hole, shift 10cm W, target 15 near NE corner of template	Dieter	Kevin	Brian
E0208107AT	N070E143	20	same location as target 101, shift 10cm N, target 116 at E edge of template	Dieter	Kevin	Brian
E0208107AU	N070E143	51	same location as target 115, shift 10cm NW, target 29 (85, 126) near NE corner, target 94 near SE corner of template	Dieter	Kevin	Brian
E0208107AV	N070E143	94	target 15 near SW corner , target 51 (115) near NW corner	Dieter	Kevin	Brian
E0208107AW	N070E143	82	same location as targets 119 and 148, uneven surface stump	Dieter	Kevin	Brian
E0208107AX	N070E144	Static-spike-spike-static	changing from erdc to csm1 battery	Dieter	Kevin	Brian
E0208107AY	N070E144	Static-spike-spike-static	after changing battery	Kevin	Dieter	Brian
E0208107AZ	N070E143	1	uneven surface stump, hole, shifting template north 10cm	Kevin	Dieter	Brian
E0208107BA	N070E143	36	same location as target 45	Kevin	Dieter	Brian
E0208107BB	N070E143	13	shifting template 10cm west, target 140 near west edge, target 1 near SW corner, target 54 near se corner, uneven surface slope. Computer log indicated this was target 14 yet the photos have it listed as target 13, go with the photos??	Kevin	Dieter	Brian
E0208107BC	N070E143	72	shifting template 10cm NE, target 54 near NE corner, target 1 near NW corner, point 19 is off (tree)	Kevin	Dieter	Brian
E0208107BD	N070E143	43	same location as target 63, shifting template 10cm north, target 44 near eastern edge, target 108 near southern edge, uneven surface drop off, pulling cart for points 20 to 33	Kevin	Dieter	Brian
E0208107BE	N070E143	74	shifted template 20cm north, target 105 near NE corner	Kevin	Dieter	Brian
E0208107BF	N070E143	3	same location as target 18, shift 20cm north	Kevin	Dieter	Brian
E0208107BG	N070E143	48	target 3(18) near western edge	Kevin	Dieter	Brian
E0208107BH	N082E144	Static-spike-spike-static	end of day test with both sphere and McClellan item	Kevin	Dieter	Brian
E0208107BI	N082E144	tilt test	end of day tilt test, right wheel up, left wheel up, pitch forward	Kevin	Dieter	Brian
		notes	using the entire CSM system today			
			EM61 reaq team was scheduled to working nearby, but kept them at least 150 feet away at all times			

APPENDIX F: GROUND TRUTH

The table below lists the ground truth information provided by Matrix Environmental. Many of the MEC scrap items were in-fact 75mm or 3.8" rounds that were only missing the lead-shot (the shot had been ejected on detonation). We assumed that any MEC scrap that was a 75 shrapnel round weighing 10 pounds or a 3.8" shrapnel round weighing 15 pounds was in fact an intact "Medium MEC". The designation in the "Type" column indicates whether the item was in the Training or Test data sets.

Grid	Unique_ID	Label	Easting SP	Northing SP	Nature of Dig	Comment	Inferred type	Wt Dig lbs	Qty Dig	Depth (m)	Type
N072E145	N072E145_002	1	673,665.12	1,162,243.61	QC Seed	75mm Shrapnel	Medium MEC	4	1	0.20	Test
N072E145	N072E145_013	2	673,615.12	1,162,232.56	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.20	Training
N072E145	N072E145_010	3	673,607.62	1,162,256.79	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.36	Test
N072E144	N072E144_042	4	673,595.12	1,162,221.96	Non-MEC Scrap	Metal Debris	Cultural debris	0.5	1	0.00	Test
N072E144	N072E144_026	5	673,597.10	1,162,250.87	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.46	Test
N072E144	N072E144_029	6	673,555.65	1,162,256.07	Demo	3.8 Inch Shrapnel	Medium MEC	15	1	0.20	Training
N072E144	N072E144_039	7	673,567.62	1,162,280.24	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.61	Test
N072E144	N072E144_004	8	673,545.13	1,162,256.97	MEC Scrap	75mm Shrapnel;3.8 Inch Shrapnel	MEC Scrap	15	3	0.61	Test
N072E144	N072E144_025	9	673,531.47	1,162,282.77	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.61	Test
N072E144	N072E144_019	10	673,538.08	1,162,218.19	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	2	0.46	Test
N072E144	N072E144_044	11	673,547.63	1,162,194.28	MEC Frag	3.8 Inch Shrapnel	MEC Scrap	0.5	1	0.30	Training
N072E144	N072E144_011	12	673,575.13	1,162,204.10	Demo	75mm Shrapnel	Medium MEC	10	1	0.36	Test
N072E144	N072E144_008	13	673,555.54	1,162,186.92	MEC Scrap	75mm Shrapnel; Spitback Tube	MEC Scrap	7	2	0.61	Test
N072E144	N072E144_005	14	673,520.13	1,162,184.78	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Test
N072E144	N072E144_041	15	673,585.12	1,162,199.50	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.10	Test
N072E144	N072E144_032	16	673,600.12	1,162,262.51			No find	NaN		NaN	Test
N072E143	N072E143_005	17	673,457.63	1,162,208.22	MEC Frag	75mm Shrapnel	MEC Scrap	2	1	0.46	Test
N072E143	N072E143_001	18	673,462.63	1,162,219.86	MEC Scrap	75mm Shrapnel;3.8 Inch Shrapnel	MEC Scrap	15	2	0.46	Test
N072E143	N072E143_020	19	673,448.02	1,162,269.39	MEC Scrap	Fuze;3.8 Inch Shrapnel	MEC Scrap	10	2	0.61	Training
N072E143	N072E143_002	20	673,415.12	1,162,217.30	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.15	Test
N072E143	N072E143_062	21	673,410.12	1,162,273.41	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.05	Test
N072E143	N072E143_026	22	673,447.63	1,162,232.86	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.41	Test
N072E143	N072E143_055	23	673,445.12	1,162,248.99	MEC Scrap	Fuze	MEC Scrap	1	1	0.10	Test
N072E143	N072E143_036	24	673,475.48	1,162,236.83	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.41	Training
N072E143	N072E143_006	25	673,462.63	1,162,245.09	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.30	Test
N072E143	N072E143_044	26	673,420.13	1,162,203.23	MEC Frag	3.8 Inch Shrapnel	MEC Scrap	0.5	1	0.46	Test
N072E142	N072E142_040	27	673,392.62	1,162,185.61	Non-MEC Scrap	N/A	Cultural debris	0.5	1	0.05	Test
N072E142	N072E142_033	28	673,377.62	1,162,204.03	MEC Scrap	75mm Shrapnel	MEC Scrap	0.5	1	0.20	Test
N072E142	N072E142_007	29	673,390.12	1,162,221.10	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.61	Test
N072E142	N072E142_004	30	673,375.12	1,162,247.10	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.30	Training
N072E142	N072E142_003	31	673,392.62	1,162,273.67	MEC Scrap	75mm Shrapnel	MEC Scrap	3	2	0.46	Test
N072E142	N072E142_008	32	673,362.62	1,162,243.08	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Training
N072E142	N072E142_032	33	673,357.62	1,162,195.80	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.15	Test
N072E142	N072E142_016	34	673,347.62	1,162,203.24	Non-MEC Scrap	Horseshoe(s)	Cultural debris	0.5	1	0.15	Test
N072E141	N072E141_009	35	673,300.11	1,162,194.49	Non-MEC Scrap	N/A	Cultural debris	0.5	2	0.08	Training
N072E141	N072E141_011	36	673,307.51	1,162,225.99	MEC Frag	75mm (HE)	MEC Scrap	0.5	0	0.05	Test
N072E141	N072E141_003	37	673,265.09	1,162,238.73	MEC Scrap	Fuze	MEC Scrap	1	1	0.20	Test

Grid	Unique_ID	Label	Easting SP	Northing SP	Nature of Dig	Comment	Inferred type	Wt Dig lbs	Qty Dig	Depth (m)	Type
N072E141	N072E141_013	38	673,290.10	1,162,257.53	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.08	Test
N072E141	N072E141_006	39	673,300.10	1,162,280.70	MEC Frag	75mm (HE)	MEC Scrap	0	1	0.05	Training
N072E141	N072E141_001	40	673,285.10	1,162,272.10	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.20	Test
N072E141	N072E141_010	41	673,250.08	1,162,269.86	Non-MEC Scrap	Horseshoe(s)	Cultural debris	0.5	1	0.10	Test
N071E141	N071E141_005	42	673,303.01	1,162,167.62	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.20	Test
N071E141	N071E141_007	43	673,272.61	1,162,157.31	MEC Scrap	3.8 Inch Shrapnel; Spitback Tube	MEC Scrap	10	2	0.61	Test
N071E141	N071E141_020	44	673,245.10	1,162,175.38	Non-MEC Scrap	Metal Can(s)	Cultural debris	0.5	2	0.08	Test
N071E141	N071E141_038	45	673,220.11	1,162,126.59	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.20	Test
N071E141	N071E141_016	46	673,207.73	1,162,096.66	MEC Scrap	75mm Shrapnel	MEC Scrap	0.5	1	0.00	Test
N071E141	N071E141_033	47	673,245.12	1,162,100.39	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.15	Test
N071E141	N071E141_002	48	673,295.11	1,162,148.76	MEC Scrap	Fuze;3.8 Inch Shrapnel	MEC Scrap	10	2	0.46	Test
N071E141	N071E141_011	49	673,267.62	1,162,115.88	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.10	Test
N071E142	N071E142_013	50	673,312.61	1,162,093.31	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.30	Training
N071E142	N071E142_024	51	673,342.62	1,162,097.48	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Test
N071E142	N071E142_006	52	673,317.61	1,162,168.77	MEC Scrap	Fuze	MEC Scrap	2	2	0.61	Test
N071E142	N071E142_030	53	673,352.62	1,162,142.06	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.46	Test
N071E142	N071E142_067	54	673,374.79	1,162,117.49	Non-MEC Scrap	N/A	Cultural debris	0.5	4	0.20	Test
N071E142	N071E142_010	55	673,385.13	1,162,124.76	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.61	Training
N071E142	N071E142_033	56	673,375.13	1,162,110.22	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.91	Test
N071E142	N071E142_025	57	673,385.13	1,162,109.31	MEC Frag	75mm Shrapnel	MEC Scrap	3	3	0.36	Training
N071E142	N071E142_004	58	673,390.13	1,162,098.28	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Test
N071E142	N071E142_026	59	673,387.63	1,162,116.60	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	3	0.46	Test
N071E142	N071E142_012	60	673,407.53	1,162,121.37	MEC Scrap	Fuze	MEC Scrap	1	1	0.25	Training
N071E142	N071E142_016	61	673,407.53	1,162,129.69	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Training
N071E143	N071E143_051	62	673,421.09	1,162,148.90	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.46	Test
N071E143	N071E143_012	63	673,415.13	1,162,132.21	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Test
N071E143	N071E143_020	64	673,447.63	1,162,170.19	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.46	Test
N071E143	N071E143_007	65	673,477.63	1,162,151.53	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Test
N071E143	N071E143_087	66	673,457.63	1,162,161.51	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.23	Test
N071E143	N071E143_016	67	673,470.13	1,162,169.98	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.30	Test
N071E143	N071E143_027	68	673,497.64	1,162,154.79	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.61	Test
N071E143	N071E143_041	69	673,475.14	1,162,109.79	Demo	3.8 Inch Shrapnel	Medium MEC	15	1	0.91	Test
N071E143	N071E143_072	70	673,480.14	1,162,093.57	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.15	Test
N071E143	N071E143_050	71	673,497.64	1,162,161.06	MEC Frag	3.8 Inch Shrapnel	MEC Scrap	0.5	1	0.15	Test
N071E143	N071E143_003	72	673,435.13	1,162,113.68	Demo	3.8 Inch Shrapnel	Medium MEC	15	1	0.46	Training
N071E143	N071E143_081	73	673,430.13	1,162,133.69	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.15	Test
N071E143	N071E143_028	74	673,432.63	1,162,117.80	Demo	3.8 Inch Shrapnel	Medium MEC	15	1	0.46	Training
N071E143	N071E143_022	75	673,425.36	1,162,107.21	Demo	75mm Shrapnel	Medium MEC	7	1	0.30	Test
N071E143	N071E143_044	76	673,452.63	1,162,139.87	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.91	Test
N071E143	N071E143_035	77	673,457.63	1,162,127.30	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.46	Training
N072E143	N072E143_030	78	673,460.13	1,162,186.08	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.46	Test
N072E143	N072E143_004	79	673,432.62	1,162,247.74	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Test
N072E143	N072E143_019	80	673,445.13	1,162,241.76	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Test
N072E143	N072E143_017	81	673,450.13	1,162,242.59	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.61	Test
N072E143	N072E143_023	82	673,497.63	1,162,226.26	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.41	Test
N072E144	N072E144_020	83	673,520.13	1,162,234.10	Demo	75mm Shrapnel	Medium MEC	10	1	0.15	Test
N072E144	N072E144_015	84	673,527.05	1,162,215.35	MEC Scrap	75mm Shrapnel	MEC Scrap	7	2	0.61	Test

Grid	Unique_ID	Label	Easting SP	Northing SP	Nature of Dig	Comment	Inferred type	Wt Dig lbs	Qty Dig	Depth (m)	Type
N072E144	N072E144_001	85	673,525.13	1,162,235.91	Demo	75mm Shrapnel	Medium MEC	10	1	0.15	Training
N071E144	N071E144_048	86	673,515.13	1,162,182.30	MEC Frag	Spitback Tube	MEC Scrap	0.5	1	0.00	Test
N071E144	N071E144_006	87	673,515.52	1,162,163.60	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Test
N071E144	N071E144_011	88	673,517.64	1,162,125.98	MEC Frag	3.8 Inch Shrapnel	MEC Scrap	3	2	0.91	Test
N071E144	N071E144_012	89	673,514.78	1,162,154.21	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.91	Test
N071E144	N071E144_042	90	673,510.14	1,162,122.37	MEC Frag	Fuze	MEC Scrap	0.5	1	0.15	Test
N071E144	N071E144_017	91	673,542.63	1,162,140.36	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.61	Test
N071E144	N071E144_029	92	673,557.38	1,162,120.18	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.91	Test
N071E144	N071E144_023	93	673,548.17	1,162,150.38	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.61	Test
N071E144	N071E144_008	94	673,578.05	1,162,116.10	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Test
N071E144	N071E144_021	95	673,565.13	1,162,142.21	MEC Frag	Spitback Tube	MEC Scrap	0.5	1	0.30	Test
N071E144	N071E144_007	96	673,589.83	1,162,182.58	QA Seed	75mm Shrapnel	Medium MEC	7	1	0.30	Test
N071E144	N071E144_003	97	673,565.13	1,162,136.34	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Test
N071E144	N071E144_015	98	673,589.84	1,162,164.42	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.91	Training
N071E145	N071E145_003	99	673,612.62	1,162,088.77	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Test
N071E145	N071E145_001	100	673,615.12	1,162,165.27	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.33	Test
N071E145	N071E145_002	101	673,655.13	1,162,098.80	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	2	0.30	Test
N071E145	N071E145_005	102	673,630.12	1,162,105.34	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.91	Test
N071E145	N071E145_004	103	673,702.63	1,162,142.95	MEC Scrap	Fuze	MEC Scrap	1	1	0.08	Test
N071E146	N071E146_007	104	673,732.63	1,162,130.59	Non-MEC Scrap	N/A	Cultural debris	0	3	0.10	Training
N071E146	N071E146_002	105	673,792.62	1,162,115.94	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.46	Test
N071E146	N071E146_001	106	673,802.62	1,162,125.76	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.30	Test
N071E146	N071E146_008	107	673,807.62	1,162,098.23	MEC Scrap	Fuze; 75mm Shrapnel	MEC Scrap	8	2	0.30	Test
N071E146	N071E146_005	108	673,805.12	1,162,119.79	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.46	Test
N071E146	N071E146_006	109	673,805.12	1,162,100.37	Non-MEC Scrap	N/A	Cultural debris	0.5	1	0.08	Training
N071E147	N071E147_009	110	673,847.62	1,162,135.11	MEC Frag	75mm (HE)	MEC Scrap	0.5	2	0.20	Test
N071E147	N071E147_008	111	673,892.63	1,162,148.62	MEC Scrap	Fuze	MEC Scrap	1	1	0.18	Training
N071E148	N071E148_017	112	673,912.64	1,162,086.96	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.23	Test
N071E148	N071E148_010	113	673,942.63	1,162,115.92	MEC Scrap	Rifle Grenade (Illumination)	MEC Scrap	1	1	0.08	Test
N071E148	N071E148_021	114	673,935.13	1,162,090.43	MEC Scrap	Fuze	MEC Scrap	1	1	0.20	Test
N071E149	N071E149_008	115	674,060.12	1,162,098.92	Non-MEC Scrap	N/A	Cultural debris	0.5	4	0.05	Test
N071E149	N071E149_013	116	674,075.12	1,162,108.57	MEC Frag	75mm (HE)	MEC Scrap	0.5	2	0.08	Test
N071E150	N071E150_001	117	674,147.62	1,162,122.62	QC Seed	75mm Shrapnel	Medium MEC	7	1	0.30	Test
N071E150	N071E150_007	118	674,112.63	1,162,157.54	Small Arms	Small Arms Ammo	Small-arms	0.5	3	0.05	Test
N071E150	N071E150_004	119	674,177.62	1,162,095.06	MEC Scrap	Fuze	MEC Scrap	1	1	0.00	Test
N071E150	N071E150_003	120	674,207.52	1,162,131.36	QA Seed	3.5 Inch Rocket	Small-medium MEC	1	1	0.15	Test
N071E150	N071E150_009	121	674,195.12	1,162,140.49	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.13	Test
N071E152	N071E152_008	122	674,310.12	1,162,109.78	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.18	Test
N071E152	N071E152_005	123	674,390.13	1,162,107.49	MEC Scrap	Trip Flare	MEC Scrap	0.5	1	0.08	Test
N073E144	N073E144_002	124	673,577.62	1,162,342.61	MEC Frag	3.8 Inch Shrapnel	MEC Scrap	4	3	0.46	Test
N073E144	N073E144_013	125	673,575.12	1,162,364.67	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.46	Test
N073E144	N073E144_017	126	673,560.12	1,162,329.21	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.25	Training
N073E144	N073E144_014	127	673,555.45	1,162,316.39	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.46	Training
N073E144	N073E144_003	128	673,535.13	1,162,354.85	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.30	Training
N073E144	N073E144_019	129	673,552.29	1,162,311.72	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.46	Training
N073E144	N073E144_010	130	673,547.62	1,162,345.93	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.30	Test
N073E144	N073E144_032	131	673,532.63	1,162,284.16	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.00	Test

Grid	Unique_ID	Label	Easting SP	Northing SP	Nature of Dig	Comment	Inferred type	Wt Dig lbs	Qty Dig	Depth (m)	Type
N073E144	N073E144_001	132	673,515.13	1,162,374.57	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.36	Test
N073E144	N073E144_028	133	673,517.63	1,162,300.41	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.03	Test
N073E144	N073E144_021	134	673,542.63	1,162,326.24	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.46	Test
N073E144	N073E144_020	135	673,525.13	1,162,297.82	Non-MEC Scrap	Metal Plate	Cultural debris	1	1	0.00	Training
N073E144	N073E144_022	136	673,522.63	1,162,328.91	MEC Scrap	Fuze	MEC Scrap	3	1	0.10	Test
N073E144	N073E144_008	137	673,510.13	1,162,313.49	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.20	Test
N073E143	N073E143_009	138	673,492.63	1,162,344.16	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.38	Test
N073E143	N073E143_023	139	673,495.13	1,162,302.57	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.30	Test
N073E143	N073E143_032	140	673,477.63	1,162,347.35	Demo	75mm Shrapnel	Medium MEC	10	1	0.30	Test
N073E143	N073E143_031	141	673,482.63	1,162,299.96	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.30	Test
N073E143	N073E143_019	142	673,482.63	1,162,352.91	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.46	Test
N073E143	N073E143_003	143	673,442.62	1,162,293.05	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.25	Test
N073E143	N073E143_002	144	673,470.26	1,162,373.63	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.30	Test
N073E143	N073E143_006	145	673,467.62	1,162,362.65	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.41	Test
N072E143	N072E143_018	146	673,437.63	1,162,192.21	MEC Scrap	Fuze; 3.8 Inch Shrapnel	MEC Scrap	10	2	0.61	Test
N073E143	N073E143_036	147	673,455.12	1,162,357.05	Demo	75mm Shrapnel	Medium MEC	10	1	0.30	Test
N073E143	N073E143_044	148	673,452.62	1,162,350.68	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.25	Training
N073E143	N073E143_021	149	673,425.12	1,162,360.42	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.46	Test
N073E143	N073E143_029	150	673,417.62	1,162,324.68	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.46	Test
N073E142	N073E142_001	151	673,362.61	1,162,337.13	MEC Scrap	75mm (HE)	Medium MEC	10	1	0.61	Training
N073E142	N073E142_010	152	673,370.10	1,162,370.89	MEC Frag	75mm (HE)	MEC Scrap	2	5	0.25	Test
N073E142	N073E142_002	153	673,394.90	1,162,370.26	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.91	Test
N073E142	N073E142_015	154	673,352.61	1,162,303.18	MEC Scrap	Fuze	MEC Scrap	3	1	0.30	Test
N073E142	N073E142_003	155	673,362.60	1,162,357.16	MEC Scrap	Fuze	MEC Scrap	3	1	0.08	Test
N073E142	N073E142_005	156	673,340.11	1,162,293.99	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.30	Test
N073E142	N073E142_011	157	673,327.63	1,162,350.04	MEC Frag	75mm (HE)	MEC Scrap	1	3	0.10	Test
N073E142	N073E142_012	158	673,339.85	1,162,287.37	MEC Scrap	75mm Shrapnel	MEC Scrap	1	1	0.18	Test
N073E142	N073E142_006	159	673,340.11	1,162,309.08	Demo	3 Inch Stokes Mortar	Medium MEC	15	1	0.41	Test
N073E142	N073E142_007	160	673,322.61	1,162,294.14	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.41	Test
N071E141	N071E141_013	161	673,220.12	1,162,096.22	Demo	37mm HE;75mm Shrapnel	Small-medium MEC	1	2	0.00	Test
N073E141	N073E141_002	162	673,237.56	1,162,334.98	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.61	Test
N073E141	N073E141_001	163	673,232.54	1,162,368.75	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.36	Test
N073E141	N073E141_011	164	673,275.08	1,162,375.41	Non-MEC Scrap	N/A	Cultural debris	0.5	1	0.00	Test
N074E141	N074E141_006	165	673,295.09	1,162,407.16	Non-MEC Scrap	Barbed Wire	Cultural debris	0.5	1	0.03	Test
N074E141	N074E141_005	166	673,267.57	1,162,385.71	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.91	Test
N074E141	N074E141_008	167	673,242.54	1,162,404.68	MEC Scrap	Fuze	MEC Scrap	3	1	0.38	Test
N074E142	N074E142_015	168	673,322.49	1,162,482.79	MEC Scrap	Fuze	MEC Scrap	3	1	0.25	Test
N074E142	N074E142_001	169	673,322.63	1,162,401.33	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.30	Test
N074E142	N074E142_009	170	673,339.95	1,162,461.89	Non-MEC Scrap	Barbed Wire	Cultural debris	0.5	1	0.03	Test
N074E142	N074E142_012	171	673,375.08	1,162,416.11	MEC Frag	75mm (HE)	MEC Scrap	1	3	0.25	Training
N074E142	N074E142_022	172	673,360.11	1,162,429.85	MEC Scrap	75mm Shrapnel	MEC Scrap	1	1	0.18	Test
N074E142	N074E142_004	173	673,394.91	1,162,415.13	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.30	Test
N074E143	N074E143_012	174	673,417.62	1,162,431.99	MEC Scrap	Fuze	MEC Scrap	3	1	0.15	Test
N074E143	N074E143_006	175	673,450.12	1,162,400.34	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.46	Test
N074E143	N074E143_009	176	673,500.13	1,162,397.87	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.30	Training
N074E143	N074E143_007	177	673,487.63	1,162,385.69	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.36	Test
N074E143	N074E143_023	178	673,500.13	1,162,419.03	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.15	Test

Grid	Unique_ID	Label	Easting SP	Northing SP	Nature of Dig	Comment	Inferred type	Wt Dig lbs	Qty Dig	Depth (m)	Type
N074E143	N074E143_017	179	673,472.62	1,162,425.09	MEC Scrap	75mm Shrapnel	MEC Scrap	1	1	0.46	Test
N074E143	N074E143_011	180	673,490.12	1,162,442.58	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.61	Test
N074E143	N074E143_026	181	673,485.12	1,162,479.44	Non-MEC Scrap	N/A	Cultural debris	0.5	2	0.03	Test
N074E143	N074E143_021	182	673,507.52	1,162,473.48			No find	NaN		NaN	Test
N074E144	N074E144_044	183	673,530.12	1,162,481.38	Non-MEC Scrap	Barbed Wire	Cultural debris	0.5	3	0.10	Test
N074E144	N074E144_004	184	673,520.12	1,162,426.18	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.91	Test
N074E144	N074E144_045	185	673,550.53	1,162,439.94	Non-MEC Scrap	N/A	Cultural debris	0.5	2	0.08	Test
N074E144	N074E144_009	186	673,542.62	1,162,438.28	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.30	Training
N074E144	N074E144_030	187	673,537.62	1,162,434.85	Non-MEC Scrap	Bolt(s)	Cultural debris	0.5	1	0.03	Test
N074E144	N074E144_019	188	673,567.62	1,162,399.40	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.30	Test
N074E144	N074E144_006	189	673,590.12	1,162,417.54	MEC Scrap	75mm Shrapnel	Medium MEC	10	2	0.46	Test
N074E144	N074E144_007	190	673,582.62	1,162,417.14	MEC Scrap	75mm Shrapnel	Medium MEC	15	2	0.30	Test
N074E144	N074E144_005	191	673,590.12	1,162,424.41	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.25	Test
N072E146	N072E146_014	192	673,750.12	1,162,280.55	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.03	Test
N072E146	N072E146_001	193	673,722.62	1,162,279.16	MEC Scrap	Fuze	MEC Scrap	1	1	0.05	Test
N072E146	N072E146_004	194	673,757.18	1,162,267.26	MEC Frag	75mm (HE)	MEC Scrap	1	1	0.03	Test
N072E146	N072E146_007	195	673,715.12	1,162,272.66	MEC Scrap	75mm Shrapnel	MEC Scrap	1	1	0.10	Test
N072E146	N072E146_002	196	673,717.62	1,162,269.47	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.30	Training
N072E146	N072E146_008	197	673,722.62	1,162,264.79	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.05	Test
N072E146	N072E146_011	198	673,767.62	1,162,273.40	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.05	Test
N072E147	N072E147_010	199	673,837.62	1,162,247.57	MEC Frag	75mm (HE);75mm Shrapnel;Small Arms Ammo	MEC Scrap	8	5	1.22	Test
N072E147	N072E147_008	200	673,815.12	1,162,213.53	MEC Scrap	Metal Pipe	MEC Scrap	4	1	0.13	Test
N072E147	N072E147_007	201	673,842.62	1,162,260.11	MEC Scrap	Fuze	MEC Scrap	1	1	0.13	Training
N072E147	N072E147_017	202	673,855.12	1,162,243.81	Non-MEC Scrap	N/A	Cultural debris	0.5	1	0.20	Test
N072E147	N072E147_004	203	673,875.12	1,162,228.60	Demo	75mm Shrapnel	Medium MEC	7	1	0.23	Test
N072E147	N072E147_018	204	673,892.62	1,162,240.63	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.00	Test
N072E148	N072E148_003	205	673,932.62	1,162,244.28	MEC Frag	75mm (HE)	MEC Scrap	0.5	2	0.20	Test
N072E148	N072E148_001	206	673,982.63	1,162,202.99	Demo	75mm Shrapnel	Medium MEC	10	1	0.61	Training
N072E148	N072E148_002	207	673,967.62	1,162,278.27	Non-MEC Scrap	N/A	Cultural debris	0.5	4	0.15	Test
N072E148	N072E148_008	208	673,955.12	1,162,265.04	MEC Frag	75mm (HE)	MEC Scrap	0.5	3	0.10	Test
N072E149	N072E149_001	209	674,045.13	1,162,213.08	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.08	Test
N072E150	N072E150_003	210	674,119.84	1,162,225.74	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.20	Test
N072E150	N072E150_005	211	674,140.13	1,162,220.86	MEC Scrap	Fuze	MEC Scrap	1	1	0.05	Test
N072E151	N072E151_002	212	674,222.62	1,162,227.89	MEC Scrap	Fuze	MEC Scrap	1	1	0.15	Test
N072E151	N072E151_008	213	674,297.62	1,162,265.66	MEC Frag	37mm HE	MEC Scrap	0.5	1	0.13	Test
N072E151	N072E151_006	214	674,307.52	1,162,211.91	Non-MEC Scrap	Horseshoe(s)	Cultural debris	1	1	0.10	Test
N072E151	N072E151_004	215	674,307.52	1,162,202.24	Non-MEC Scrap	Horseshoe(s)	Cultural debris	1	1	0.00	Test
N077E145	N077E145_007	216	673,630.12	1,162,783.21	MEC Scrap	75mm Shrapnel	MEC Scrap	1	1	0.25	Test
N077E145	N077E145_005	217	673,687.84	1,162,746.34	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.46	Test
N077E145	N077E145_023	218	673,680.50	1,162,747.71	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.13	Test
N077E145	N077E145_003	219	673,640.12	1,162,708.21	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	25	2	0.61	Test
N077E144	N077E144_008	220	673,599.02	1,162,724.18	MEC Frag	75mm (HE)	MEC Scrap	2	1	0.18	Test
N077E144	N077E144_031	221	673,572.61	1,162,690.40	Non-MEC Scrap	Banding Material	Cultural debris	0.5	1	0.05	Training
N077E144	N077E144_016	222	673,507.61	1,162,690.35	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.00	Test
N077E144	N077E144_006	223	673,597.61	1,162,759.15	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.00	Test
N077E144	N077E144_004	224	673,540.12	1,162,756.74	MEC Frag	75mm (HE)	MEC Scrap	1	2	0.61	Test
N077E144	N077E144_017	225	673,522.62	1,162,765.67	MEC Scrap	Fuze	MEC Scrap	3	1	0.20	Test

Grid	Unique_ID	Label	Easting SP	Northing SP	Nature of Dig	Comment	Inferred type	Wt Dig lbs	Qty Dig	Depth (m)	Type
N077E143	N077E143_001	226	673,497.61	1,162,761.20	MEC Frag	75mm (HE)	MEC Scrap	2	1	0.08	Test
N077E143	N077E143_002	227	673,447.62	1,162,770.39	MEC Frag	75mm (HE)	MEC Scrap	3	1	0.41	Test
N077E143	N077E143_024	228	673,452.60	1,162,684.11	Non-MEC Scrap	Barbed Wire	Cultural debris	0.5	2	0.15	Test
N077E143	N077E143_075	229	673,477.60	1,162,688.97	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.08	Training
N078E143	N078E143_022	230	673,410.13	1,162,792.90	MEC Scrap	Fuze	MEC Scrap	3	1	0.30	Test
N078E143	N078E143_025	231	673,467.25	1,162,834.29	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.03	Test
N078E143	N078E143_015	232	673,432.64	1,162,847.60	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.10	Test
N078E143	N078E143_031	233	673,452.63	1,162,814.54	Non-MEC Scrap	N/A	Cultural debris	0.5	1	0.20	Training
N078E143	N078E143_007	234	673,477.63	1,162,852.19	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.61	Test
N078E143	N078E143_010	235	673,497.63	1,162,846.26	Demo	3.8 Inch Shrapnel	Medium MEC	15	1	0.61	Test
N078E144	N078E144_008	236	673,542.62	1,162,804.05	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.05	Training
N078E144	N078E144_003	237	673,550.13	1,162,880.74	QC Seed	60mm Mortar (HE)	Small-medium MEC	6	1	0.05	Training
N078E144	N078E144_001	238	673,585.12	1,162,804.30	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.30	Training
N078E144	N078E144_006	239	673,560.13	1,162,861.79	Small Arms	Small Arms Ammo	Small-arms	0.5	1	0.08	Test
N078E144	N078E144_002	240	673,545.13	1,162,826.16	Demo	3.8 Inch Shrapnel	Medium MEC	15	1	0.61	Test
N078E144	N078E144_004	241	673,580.13	1,162,856.37	Non-MEC Scrap	Metal Plate	Cultural debris	1	1	0.18	Training
N078E145	N078E145_019	242	673,655.12	1,162,789.15	Non-MEC Scrap	Horseshoe(s)	Cultural debris	1	1	0.10	Test
N078E145	N078E145_011	243	673,612.62	1,162,810.39	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.15	Test
N078E145	N078E145_001	244	673,662.63	1,162,850.40	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.61	Test
N078E145	N078E145_003	245	673,645.13	1,162,873.84	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.23	Training
N078E145	N078E145_009	246	673,650.13	1,162,881.65	MEC Frag	75mm (HE)	MEC Scrap	1	1	0.03	Test
N078E145	N078E145_020	247	673,657.63	1,162,865.40	MEC Frag	37mm HE	MEC Scrap	0.5	1	0.03	Test
N078E145	N078E145_022	248	673,697.63	1,162,859.79	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.10	Test
N079E144	N079E144_002	249	673,590.14	1,162,960.70	Non-MEC Scrap	Metal Plate	Cultural debris	2	1	0.05	Test
N079E144	N079E144_010	250	673,538.23	1,162,897.23	MEC Scrap	Fuze	MEC Scrap	3	1	0.05	Test
N079E144	N079E144_029	251	673,537.64	1,162,890.07	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.05	Test
N079E144	N079E144_001	252	673,562.64	1,162,923.20	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.30	Test
N079E144	N079E144_006	253	673,567.63	1,162,899.13	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.30	Test
N079E144	N079E144_007	254	673,602.63	1,162,919.45	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.61	Test
N079E144	N079E144_004	255	673,582.64	1,162,934.14	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.46	Test
N079E144	N079E144_013	256	673,550.14	1,162,959.13	MEC Scrap	Fuze	MEC Scrap	3	1	0.25	Test
N079E144	N079E144_021	257	673,560.14	1,162,963.51	Non-MEC Scrap	Barbed Wire	Cultural debris	0.5	1	0.00	Training
N079E144	N079E144_030	258	673,552.64	1,162,951.01	Non-MEC Scrap	N/A	Cultural debris	0.5	7	0.08	Training
N079E143	N079E143_021	259	673,490.14	1,162,972.89	MEC Scrap	75mm (HE)	MEC Scrap	0.5	1	0.00	Test
N079E143	N079E143_001	260	673,417.64	1,162,983.51	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.30	Test
N079E143	N079E143_018	261	673,417.64	1,162,974.76	MEC Scrap	75mm Shrapnel	MEC Scrap	1	1	0.08	Test
N079E143	N079E143_017	262	673,440.14	1,162,951.63	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.00	Test
N079E143	N079E143_015	263	673,455.14	1,162,962.57	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.05	Test
N080E143	N080E143_002	264	673,412.64	1,163,030.07	MEC Scrap	Fuze	MEC Scrap	3	1	0.10	Test
N080E143	N080E143_021	265	673,470.14	1,162,986.32	MEC Scrap	Fuze	MEC Scrap	3	1	0.00	Test
N080E143	N080E143_019	266	673,479.61	1,162,988.55	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.08	Test
N080E143	N080E143_008	267	673,492.09	1,162,985.60	MEC Scrap	Fuze	MEC Scrap	3	1	0.03	Test
N080E143	N080E143_012	268	673,460.14	1,162,985.70	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.05	Test
N080E143	N080E143_015	269	673,445.14	1,163,021.95	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.03	Test
N080E143	N080E143_005	270	673,482.64	1,163,005.70	Non-MEC Scrap	N/A	Cultural debris	0.5	15	0.00	Test
N080E143	N080E143_020	271	673,422.14	1,163,023.05	Small Arms	Small Arms Ammo	Small-arms	0.5	3	0.05	Test
N080E143	N080E143_016	272	673,467.64	1,163,020.39	MEC Frag	37mm HE	MEC Scrap	0.5	1	0.05	Test
N080E143	N080E143_013	273	673,427.64	1,163,057.88	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.08	Test

Grid	Unique_ID	Label	Easting SP	Northing SP	Nature of Dig	Comment	Inferred type	Wt Dig lbs	Qty Dig	Depth (m)	Type
N080E143	N080E143_001	274	673,505.14	1,163,026.01			No find	NaN		NaN	Test
N080E143	N080E143_004	275	673,482.64	1,163,063.20	MEC Scrap	75mm Shrapnel	MEC Scrap	1	1	0.03	Test
N080E143	N080E143_023	276	673,490.14	1,163,081.01	MEC Frag	37mm HE	MEC Scrap	0.5	1	0.00	Test
N080E144	N080E144_007	277	673,563.01	1,163,064.75	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.05	Test
N080E144	N080E144_005	278	673,527.22	1,163,015.73	MEC Scrap	Fuze	MEC Scrap	3	1	0.05	Test
N080E144	N080E144_009	279	673,552.64	1,163,012.57	MEC Scrap	75mm Shrapnel	MEC Scrap	1	1	0.00	Training
N080E144	N080E144_001	280	673,552.64	1,162,998.51	MEC Scrap	Fuze	MEC Scrap	2	2	0.30	Training
N080E144	N080E144_017	281	673,565.14	1,162,999.45	Non-MEC Scrap	Banding Material	Cultural debris	0.5	2	0.03	Test
N080E144	N080E144_019	282	673,607.64	1,162,991.95	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.05	Test
N073E151	N073E151_011	283	674,242.62	1,162,327.71	MEC Frag	37mm HE	MEC Scrap	0.5	1	0.00	Test
N073E151	N073E151_003	284	674,237.63	1,162,293.10	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.05	Test
N073E151	N073E151_009	285	674,210.13	1,162,296.49	MEC Scrap	Fuze	MEC Scrap	1	1	0.05	Test
N073E151	N073E151_010	286	674,227.63	1,162,290.40	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.05	Test
N073E151	N073E151_002	287	674,222.63	1,162,298.26	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.46	Training
N073E150	N073E150_005	288	674,192.63	1,162,301.01	MEC Scrap	Fuze	MEC Scrap	1	1	0.08	Test
N073E150	N073E150_001	289	674,107.74	1,162,320.73	MEC Scrap	Fuze;3.8“ Shrap; Spitback Tube	MEC Scrap	10	1	0.46	Test
N073E149	N073E149_018	290	674,080.13	1,162,377.04	MEC Frag	37mm HE	MEC Scrap	0.5	1	0.05	Test
N073E149	N073E149_005	291	674,065.13	1,162,355.11	MEC Frag	75mm Shrapnel	MEC Scrap	4	1	0.61	Test
N073E149	N073E149_014	292	674,020.12	1,162,366.76	Small Arms	Small Arms Ammo	Small-arms	0.5	8	0.20	Test
N073E149	N073E149_026	293	674,009.44	1,162,318.02	Small Arms	Small Arms Ammo	Small-arms	0.5	3	0.13	Training
N073E148	N073E148_006	294	673,987.62	1,162,303.87	Non-MEC Scrap	Horseshoe(s)	Cultural debris	0.5	1	0.20	Test
N073E148	N073E148_013	295	673,975.12	1,162,306.75	Small Arms	Small Arms Ammo	Small-arms	0.5	4	0.10	Test
N073E148	N073E148_004	296	673,945.12	1,162,319.68	MEC Scrap	Fuze	MEC Scrap	1	1	0.15	Test
N073E148	N073E148_010	297	673,922.89	1,162,320.87	Non-MEC Scrap	Metal Debris	Cultural debris	0.5	2	0.10	Test
N074E148	N074E148_027	298	673,925.12	1,162,389.90	MEC Scrap	Fuze	MEC Scrap	1	1	0.08	Test
N074E148	N074E148_016	299	673,932.62	1,162,450.17	Non-MEC Scrap	N/A	Cultural debris	0.5	1	0.00	Test
N074E148	N074E148_028	300	673,970.11	1,162,458.84	MEC Frag	Spitback Tube	MEC Scrap	0.5	1	0.15	Test
N074E149	N074E149_012	301	674,015.11	1,162,421.51	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.10	Test
N074E149	N074E149_011	302	674,100.13	1,162,478.97	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.15	Test
N074E149	N074E149_008	303	674,097.96	1,162,468.83	MEC Frag	75mm Shrapnel	MEC Scrap	0.5	1	0.15	Test
N074E149	N074E149_001	304	674,072.63	1,162,443.92	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.20	Test
N074E149	N074E149_003	305	674,100.13	1,162,422.63	QC Seed	75mm Shrapnel	Medium MEC	5	1	0.30	Test
N074E149	N074E149_010	306	674,077.63	1,162,388.07	Non-MEC Scrap	Horseshoe(s)	Cultural debris	0.5	1	0.10	Training
N074E149	N074E149_006	307	674,057.63	1,162,386.34	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.15	Test
N074E150	N074E150_009	308	674,145.13	1,162,415.15	MEC Frag	37mm HE	MEC Scrap	0.5	1	0.03	Test
N074E150	N074E150_010	309	674,122.63	1,162,458.84	MEC Frag	Fuze	MEC Scrap	0.5	1	0.05	Test
N077E147	N077E147_003	310	673,827.62	1,162,784.05	MEC Scrap	3.8 Inch Shrapnel	Medium MEC	15	1	0.30	Training
N077E147	N077E147_023	311	673,884.73	1,162,763.05	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.08	Test
N077E147	N077E147_054	312	673,817.62	1,162,783.16	Non-MEC Scrap	Bolt(s)	Cultural debris	0.5	1	0.05	Test
N077E147	N077E147_067	313	673,835.12	1,162,774.96	MEC Frag	37mm HE	MEC Scrap	1	1	0.05	Training
N077E147	N077E147_057	314	673,822.62	1,162,772.83	Non-MEC Scrap	Horseshoe(s)	Cultural debris	1	1	0.05	Test
N077E147	N077E147_048	315	673,817.62	1,162,765.67	Non-MEC Scrap	N/A	Cultural debris	0.5	1	0.10	Test
N077E147	N077E147_031	316	673,827.62	1,162,751.26	MEC Scrap	Fuze	MEC Scrap	3	1	0.18	Test
N077E147	N077E147_044	317	673,862.61	1,162,716.82	Non-MEC Scrap	Barbed Wire	Cultural debris	0.5	1	0.10	Test
N077E146	N077E146_024	318	673,805.12	1,162,742.59	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.05	Test
N077E146	N077E146_047	319	673,785.12	1,162,687.59	Non-MEC Scrap	N/A	Cultural debris	0.5	2	0.05	Test
N077E146	N077E146_041	320	673,805.12	1,162,761.66	Non-MEC Scrap	Aluminum Can(s)	Cultural debris	0.5	1	0.05	Test
N077E146	N077E146_025	321	673,777.62	1,162,764.47	Non-MEC Scrap	Construction	Cultural debris	0.5	2	0.08	Test

Grid	Unique_ID	Label	Easting SP	Northing SP	Nature of Dig	Comment	Inferred type	Wt Dig lbs	Qty Dig	Depth (m)	Type
						Debris					
N077E146	N077E146_031	322	673,800.12	1,162,781.03	Non-MEC Scrap	Metal Plate	Cultural debris	0.5	1	0.10	Test
N077E146	N077E146_001	323	673,730.12	1,162,764.78	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.46	Test
N077E146	N077E146_016	324	673,725.12	1,162,760.09	Non-MEC Scrap	N/A	Cultural debris	0.5	1	0.15	Test
N078E146	N078E146_065	325	673,725.12	1,162,807.60	Non-MEC Scrap	N/A	Cultural debris	0.5	7	0.25	Test
N078E146	N078E146_012	326	673,745.12	1,162,841.97	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.46	Test
N078E146	N078E146_062	327	673,775.12	1,162,852.91	Non-MEC Scrap	Bolt(s)	Cultural debris	0.5	1	0.03	Test
N078E146	N078E146_047	328	673,784.46	1,162,854.14	Non-MEC Scrap		Cultural debris	0.5	1	0.25	Test
N078E147	N078E147_002	329	673,810.12	1,162,835.05	QC Seed	75mm Shrapnel	Medium MEC	10	1	0.20	Test
N078E147	N078E147_001	330	673,887.62	1,162,808.69	Non-MEC Scrap	Metal Plate	Cultural debris	4	1	0.20	Test
N069E143	N069E143_098	331	673,467.59	1,161,896.79	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.25	Test
N069E143	N069E143_041	332	673,470.42	1,161,892.07	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.91	Test
N069E143	N069E143_021	333	673,480.17	1,161,885.82	MEC Scrap	Fuze	MEC Scrap	1	1	0.13	Test
N069E144	N069E144_028	334	673,534.62	1,161,979.24	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.91	Test
N069E144	N069E144_013	335	673,572.67	1,161,975.31	MEC Scrap	75mm Shrapnel	MEC Scrap	5	1	0.91	Test
N069E144	N069E144_019	336	673,562.67	1,161,970.24	MEC Scrap	75mm Shrapnel	MEC Scrap	3	1	0.61	Test
N069E144	N069E144_012	337	673,582.67	1,161,962.72	MEC Scrap	75mm Shrapnel	MEC Scrap	3	1	0.91	Test
N069E144	N069E144_003	338	673,567.67	1,161,980.14	MEC Scrap	75mm Shrapnel	MEC Scrap	3	1	0.30	Test
N069E144	N069E144_032	339	673,585.17	1,161,950.44	Non-MEC Scrap	Horseshoe(s)	Cultural debris	1	1	0.08	Test
N069E144	N069E144_027	340	673,577.66	1,161,911.21	Non-MEC Scrap	N/A	Cultural debris	2	1	0.05	Test
N069E144	N069E144_018	341	673,542.29	1,161,942.06	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.61	Test
N069E144	N069E144_007	342	673,513.19	1,161,950.58	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.61	Test
N069E144	N069E144_017	343	673,518.16	1,161,940.06	MEC Scrap	75mm Shrapnel	MEC Scrap	3	1	0.46	Test
N069E144	N069E144_021	344	673,507.80	1,161,925.77	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.91	Test
N069E144	N069E144_039	345	673,520.20	1,161,916.39	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.20	Training
N069E144	N069E144_030	346	673,539.51	1,161,912.17	MEC Scrap	75mm Shrapnel	MEC Scrap	0.5	1	0.10	Test
N069E144	N069E144_024	347	673,537.25	1,161,905.64	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.91	Test
N069E143	N069E143_008	348	673,492.40	1,161,981.56	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.46	Test
N069E143	N069E143_009	349	673,466.66	1,161,980.59	MEC Scrap	75mm Shrapnel	MEC Scrap	1	1	0.46	Test
N069E143	N069E143_001	350	673,472.34	1,161,934.92	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.30	Test
N069E143	N069E143_065	351	673,461.92	1,161,936.66	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.91	Test
N082E144	N082E144_024	352	673,592.21	1,163,250.01	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.00	Test
N082E144	N082E144_001	353	673,595.14	1,163,266.64	MEC Scrap	75mm Shrapnel	Medium MEC	10	1	0.30	Test
N082E144	N082E144_047	354	673,570.46	1,163,270.08	Non-MEC Scrap	N/A	Cultural debris	0.5	8	0.08	Test
N082E144	N082E144_022	355	673,597.64	1,163,229.45	Non-MEC Scrap	Metal Debris	Cultural debris	0.5	1	0.10	Test
N082E144	N082E144_003	356	673,582.64	1,163,213.20	MEC Frag	3.8 Inch Shrapnel	MEC Scrap	10	1	0.91	Test
N082E144	N082E144_048	357	673,577.94	1,163,194.76	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.00	Test
N082E144	N082E144_016	358	673,570.14	1,163,221.95	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.13	Test
N082E144	N082E144_005	359	673,559.02	1,163,212.49	Non-MEC Scrap	N/A	Cultural debris	0.5	3	0.15	Test
N082E144	N082E144_015	360	673,545.14	1,163,231.01	Small Arms	Small Arms Ammo	Small-arms	0.5	2	0.15	Test
N082E144	N082E144_039	361	673,517.64	1,163,215.39	MEC Frag	75mm (HE)	MEC Scrap	0.5	1	0.10	Test
N082E145	N082E145_025	362	673,612.64	1,163,282.97	Demo	75mm Shrapnel	Medium MEC	5	1	0.10	Test
N082E145	N082E145_006	363	673,610.14	1,163,234.14	QC Seed	60mm Mortar (HE)	Small-medium MEC	3	1	0.15	Test
N082E145	N082E145_007	364	673,610.14	1,163,227.97	MEC Scrap	75mm Shrapnel	MEC Scrap	5	1	0.61	Test
N082E145	N082E145_008	365	673,615.14	1,163,194.86	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.61	Test
N082E145	N082E145_003	366	673,635.13	1,163,205.44	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.41	Test
N082E145	N082E145_002	367	673,655.13	1,163,216.84	MEC Scrap	75mm Shrapnel	MEC Scrap	5	1	0.25	Test
N082E145	N082E145_029	368	673,662.63	1,163,200.44	Non-MEC Scrap	Metal Spike	Cultural debris	0.5	1	0.03	Test

Grid	Unique_ID	Label	Easting SP	Northing SP	Nature of Dig	Comment	Inferred type	Wt Dig lbs	Qty Dig	Depth (m)	Type
N082E145	N082E145_004	369	673,690.13	1,163,184.77	MEC Scrap	Slap Flare	MEC Scrap	0.5	1	0.10	Training
N082E145	N082E145_027	370	673,677.63	1,163,225.14	MEC Scrap	Fuze	MEC Scrap	2	1	0.05	Training
N082E145	N082E145_036	371	673,657.63	1,163,246.14	MEC Scrap	75mm Shrapnel	MEC Scrap	1	1	0.00	Training
N082E145	N082E145_028	372	673,687.63	1,163,272.18	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.05	Test
N082E145	N082E145_034	373	673,650.13	1,163,234.81	Non-MEC Scrap	Metal Debris	Cultural debris	0.5	1	0.18	Test
N081E144	N081E144_003	374	673,565.57	1,163,171.61	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.91	Training
N081E144	N081E144_001	375	673,521.38	1,163,172.70	MEC Frag	3.8 Inch Shrapnel	MEC Scrap	0.5	1	0.20	Test
N081E144	N081E144_018	376	673,575.13	1,163,117.57	Non-MEC Scrap	N/A	Cultural debris	0.5	3	0.10	Test
N069E143	N069E143_081	377	673,464.59	1,161,894.90	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.46	Test
N069E143	N069E143_028	378	673,465.05	1,161,901.17	MEC Scrap	75mm Shrapnel	MEC Scrap	3	1	0.91	Test
N069E143	N069E143_090	379	673,495.10	1,161,921.26	MEC Scrap	Spitback Tube	MEC Scrap	0.5	1	0.03	Test
N069E143	N069E143_076	380	673,489.95	1,161,952.05	MEC Scrap	75mm Shrapnel	MEC Scrap	1	1	0.46	Test
N069E143	N069E143_015	381	673,411.47	1,161,949.91	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.61	Test
N069E143	N069E143_002	382	673,411.22	1,161,963.37	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.61	Test
N069E143	N069E143_007	383	673,414.55	1,161,936.20	MEC Scrap	75mm Shrapnel	MEC Scrap	3	1	0.46	Test
N069E143	N069E143_037	384	673,408.71	1,161,962.14	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	5	1	0.61	Training
N069E143	N069E143_003	385	673,407.39	1,161,919.69	MEC Scrap	75mm Shrapnel	MEC Scrap	1	1	0.61	Test
N069E143	N069E143_023	386	673,446.74	1,161,964.01	MEC Scrap	Fuze	MEC Scrap	1	1	0.91	Test
N070E143	N070E143_008	387	673,446.62	1,161,990.21	Demo	75mm Shrapnel	Medium MEC	10	1	0.30	Test
N070E143	N070E143_029	388	673,439.22	1,162,012.71	Demo	75mm Shrapnel	Medium MEC	10	1	0.61	Test
N070E143	N070E143_028	389	673,438.98	1,161,990.79	Demo	3.8 Inch Shrapnel	Medium MEC	15	1	0.61	Test
N070E143	N070E143_020	390	673,413.42	1,161,987.03	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.46	Test
N070E143	N070E143_051	391	673,439.12	1,162,005.38	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.61	Test
N070E143	N070E143_094	392	673,444.17	1,162,003.09	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	1.22	Test
N070E143	N070E143_082	393	673,469.58	1,162,003.88	Demo	3.8 Inch Shrapnel	Medium MEC	15	1	0.91	Test
N070E143	N070E143_001	394	673,447.10	1,162,037.26	Demo	3.8 Inch Shrapnel	Medium MEC	15	1	0.91	Test
N070E143	N070E143_036	395	673,429.48	1,162,039.40	MEC Scrap	75mm Shrapnel	MEC Scrap	7	1	0.61	Test
N070E143	N070E143_013	396	673,452.20	1,162,041.99	Demo	3.8 Inch Shrapnel	Medium MEC	15	1	0.46	Training
N070E143	N070E143_072	397	673,454.67	1,162,037.21	MEC Scrap	Fuze	MEC Scrap	0.5	1	0.15	Training
N070E143	N070E143_043	398	673,424.77	1,162,061.07	MEC Scrap	3.8 Inch Shrapnel	MEC Scrap	10	1	0.61	Test
N070E143	N070E143_074	399	673,444.22	1,162,049.43	Demo	75mm Shrapnel	Medium MEC	10	1	0.61	Test
N070E143	N070E143_003	400	673,500.11	1,162,061.99	Demo	3.8 Inch Shrapnel	Medium MEC	15	1	0.91	Test
N070E143	N070E143_048	401	673,502.63	1,162,068.20	Demo	75mm Shrapnel	Medium MEC	10	1	0.30	Test
Test Pit	TP-1	402			Test-pit	Blank Grids	No find	NaN		0.00	Test
Test Pit	TP-2	403			Test-pit	Blank Grids	No find	NaN		0.00	Test
Test Pit	TP-3	404			Test-pit	2.36 inch rocket	Small-medium MEC	NaN		0.19	Training
Test Pit	TP-4	405			Test-pit	60mm mortar	Small-medium MEC	NaN		0.10	Training
Test Pit	TP-5	406			Test-pit	2.36 inch rocket	Small-medium MEC	NaN		0.18	Training
Test Pit	TP-6	407			Test-pit	60mm mortar	Small-medium MEC	NaN		0.06	Training
Test Pit	TP-7	408			Test-pit	2.36 inch rocket	Small-medium MEC	NaN		0.19	Training
Test Pit	TP-8	409			Test-pit	60mm mortar	Small-medium MEC	NaN		0.06	Training
Test Pit	TP-9	410			Test-pit	3 inch stokes mortar	Medium MEC	NaN		0.17	Training
Test Pit	TP-10	411			Test-pit	MKII grenade	Small MEC	NaN		0.06	Training
Test Pit	TP-11	412			Test-pit	3 inch stokes	Medium MEC	NaN		0.18	Training

Grid	Unique_ID	Label	Easting SP	Northing SP	Nature of Dig	Comment	Inferred type	Wt Dig lbs	Qty Dig	Depth (m)	Type
						mortar					
Test Pit	TP-12	413			Test-pit	MKII grenade	Small MEC	NaN		0.06	Training
Test Pit	TP-13	414			Test-pit	3 inch stokes mortar	Medium MEC	NaN		0.20	Training
Test Pit	TP-14	415			Test-pit	MKII grenade	Small MEC	NaN		0.07	Training
Test Pit	TP-15	416			Test-pit	3.8 inch shrap round	Medium MEC	NaN		0.20	Training
Test Pit	TP-16	417			Test-pit	37mm projectile	Small-medium MEC	NaN		0.06	Training
Test Pit	TP-17	418			Test-pit	3.8 inch shrap round	Medium MEC	NaN		0.20	Training
Test Pit	TP-18	419			Test-pit	37mm projectile	Small-medium MEC	NaN		0.06	Training
Test Pit	TP-19	420			Test-pit	3.8 inch shrap round	Medium MEC	NaN		0.20	Training
Test Pit	TP-20	421			Test-pit	37mm projectile	Small-medium MEC	NaN		0.06	Training
Test Pit	TP-21	422			Test-pit	75mm shrap round	Medium MEC	NaN		0.22	Training
Test Pit	TP-22	423			Test-pit	75mm shrap round	Medium MEC	NaN		0.20	Training
Test Pit	TP-23	424			Test-pit	75mm shrap round	Medium MEC	NaN		0.20	Training
GPO	GPO-17	425			GPO	37mm HE	Small-medium MEC	NaN		0.25	Training
GPO	GPO-67	426			GPO	75mm shrap round	Medium MEC	NaN		0.76	Training
GPO	GPO-32	427			GPO	37mm APT	Small-medium MEC	NaN		0.36	Training
GPO	GPO-51	428			GPO	3 inch stokes mortar	Medium MEC	NaN		0.81	Training
GPO	GPO-33	429			GPO	37mm APT	Small-medium MEC	NaN		0.15	Training
GPO	GPO-36	430			GPO	60mm mortar	Small-medium MEC	NaN		0.31	Training
GPO	GPO-47	431			GPO	81mm mortar light	Medium MEC	NaN		0.61	Training
GPO	GPO-37	432			GPO	60mm mortar	Small-medium MEC	NaN		0.36	Training
GPO	GPO-15	433			GPO	37mm HE	Small-medium MEC	NaN		0.20	Training
GPO	GPO-72	434			GPO	105 HEP	Medium MEC	NaN		0.91	Training
GPO	GPO-50	435			GPO	3 inch stokes mortar	Medium MEC	NaN		0.81	Training
GPO	GPO-39	436			GPO	60mm mortar	Small-medium MEC	NaN		0.46	Training
GPO	GPO-73	437			GPO	105 HEP	Medium MEC	NaN		0.91	Training
GPO	GPO-44	438			GPO	75mm shrap round	Medium MEC	NaN		0.76	Training
GPO	GPO-14	439			GPO	37mm HE	Small-medium MEC	NaN		0.15	Training
GPO	GPO-21	440			GPO	M33 grenade	Small MEC	NaN		0.10	Training
GPO	GPO-34	441			GPO	2.36 inch rocket	Small-medium MEC	NaN		0.31	Training
GPO	GPO-8	442			GPO	M67 Grenade	Small MEC	NaN		0.25	Training